NUREG-1620

Standard Review Plan

for the Review of a Reclamation Plan for Mill Tailings Sites Under Title II of the Uranium Mill Tailings Radiation Control Act

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ABSTRACT

A Nuclear Regulatory Commission source and byproduct material license is required by 10 CFR Part 40 for the operation of uranium mills and the disposal of “tailings,” wastes produced by the extraction or concentration of source material from ores processed primarily for their source material. Appendix A to Part 40 establishes technical and other criteria relating to siting, operation, decontamination, decommissioning, and reclamation of mills and of tailings at mill sites. The licensee's site reclamation plan documents how the proposed activities demonstrate compliance with the criteria in Appendix A to Part 40 and the information needed to prepare the environmental report on the effects of the proposed reclamation activities on the health and safety of the public and on the environment.

This Standard Review Plan (SRP) is prepared for the guidance of staff reviewers in the Office of Nuclear Material Safety and Safeguards in performing safety and environmental reviews of reclamation plans for uranium recovery sites covered by Title II of the Uranium Mill Tailings Radiation Control Act. It provides guidance for new reclamation plans, renewals, and amendments. The principal purpose of this SRP is to ensure the quality and uniformity of staff reviews and to present a well-defined base from which to evaluate changes in the scope and requirements of a review.

This SRP is written to cover a variety of site conditions and reclamation plans. Each section contains a description of the areas of review, review procedures, acceptance criteria, and evaluation of findings.

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LIST OF ABBREVIATIONS

ACHP	Advisory Council on Historic Preservation
ACL	alternate concentration limit
AEA	Atomic Energy Act of 1954 as amended
AEP	Archeology and Ethnography Program
ALARA	as low as reasonably achievable
ANOVA	analysis of variance
ASTM	American Society for Testing and Materials
BLM	Bureau of Land Management
CAP	corrective action program
CCR	construction completion report
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	*Code of Federal Regulations*
CPI	consumer price index
DOE	Department of Energy
EA	environmental assessment
EAP	emergency action plan
EDE	effective dose equivalent
EIS	environmental impact statement
EPA	Environmental Protection Agency
ER	environmental report
ESA	Endangered Species Act
FEMA	Federal Emergency Management Agency
FONSI	finding of no significant impact
FSTP	final staff technical position
FWS	Fish and Wildlife Service
HPS	Health Physics Society
GEIS	generic environmental impact statement
ICRP	International Commission on Radiological Protection
ISL	in situ leach
ISRM	International Society of Rock Mechanics
IUC	International Uranium Corporation
LTSP	long-term surveillance plan
MCE	maximum credible earthquake
MCL	maximum concentration limit
MDL	method detection limit
MOU	memorandum of understanding
NHPA	National Historic Preservation Act
NMA	National Mining Association
NMFS	National Marine Fisheries Service
NMSS	Office of Nuclear Material Safety and Safeguards (NRC)
NPS	National Park Service
NRC	Nuclear Regulatory Commission
OSP	Office of State Programs (NRC)
PE	probability of exceedance
PGA	peak ground acceleration
PHA	peak horizontal acceleration
PMF	probable maximum flood

LIST OF ABBREVIATIONS (cont'd)

PMP	probable maximum precipitation
POC	point of compliance
POE	point of exposure
PQL	physical quantitation limit
PSHA	probabilistic seismic hazard analysis
QA	quality assurance
QC	quality control
RAI	request for additional information
RfD	reference dose
RP	reclamation plan
RSD	risk-specific dose
SFCG	Standard Format and Content Guide
SHPO	State historical preservation officer
SRP	standard review plan
TDS	total dissolved solvent
TEDE	total effective dose equivalent
TER	technical evaluation report
THPO	tribal historic preservation officer
TLD	thermoluminescence dosimeter
TP	technical position
TVA	Tennessee Valley Authority
UMTRA	Uranium Mill Tailing Remedial Action
UMTRCA	Uranium Mill Tailings Radiation Control Act of 1978 as amended
UR	uranium recovery
WMA	Wyoming Mining Association

INTRODUCTION

A Nuclear Regulatory Commission (NRC) source and byproduct material license is required in accordance with the provisions of Title 10 of the U.S. *Code of Federal Regulations*, Part 40 (10 CFR Part 40), "Domestic Licensing of Source Material," in conjunction with uranium or thorium milling, or with byproduct material at sites formerly associated with such milling. At the termination of a uranium mill license, the mill tailings impoundment and some land will be turned over to the Department of Energy (DOE), another Federal agency designated by the President, or the State in which the site is located for long-term care. Under the Atomic Energy Act of 1954 as amended, the NRC is required to determine if all applicable requirements have been met at the time of license termination. Requirements applicable to a license consist of the regulations in 10 CFR Part 40, Appendix A to 10 CFR Part 40, and any license condition.

An application for a new license, license renewal, or an amendment to or termination of an existing license should contain, as appropriate, proposed specifications relating to the milling operations, and the information on the disposal of tailings or wastes resulting from such milling activities and information on decommissioning of the site. General guidance on (1) contents and filing of an application and (2) producing an environmental report (ER) appears 10 CFR 40.31, "Application for specific licenses," and in 10 CFR Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions," respectively. The staff uses the information in the application to determine whether the proposed activities will be protective of public health and safety and be environmentally acceptable. General provisions for issuance, amendment, transfer, and renewal of licenses are described in 10 CFR Part 2, Subpart A.

This Standard Review Plan (SRP) provides the staff in the Office of Nuclear Material Safety and Safeguards (NMSS) with specific guidance on the review of reclamation plans (RP) and license amendments related to reclamation plans. The reclamation plan (RP), submitted by an applicant (in the case of a new application) or a licensee (in the case of an amendment to a previously approved reclamation plan or termination of an existing license) should demonstrate compliance with the applicable criteria in Appendix A to Part 40. The principal purpose of the SRP is to present guidance to the NRC staff to ensure a consistent quality and uniformity in NRC reviews of RPs. Each section in this SRP contains guidance on what is to be reviewed, the basis for the review, how the staff review is to be done, what the staff will find acceptable in a demonstration of compliance with the regulations, and the conclusions that are sought regarding compliance with the regulations in 10 CFR Part 40. This SRP is intended to cover only those aspects of the NRC regulatory mission related to the reclamation of mill tailings impoundments, including ground-water cleanup, at conventional uranium mills. As such, the SRP helps focus the staff's review on determining if a tailings impoundment can be constructed, operated, and reclaimed in compliance with the applicable NRC regulations. The SRP is also intended to make information about regulatory matters widely available to improve communication, and to help interested members of the public and uranium recovery industry gain a better understanding of the staff's review process. In any of these reviews, the staff will consider licensee-proposed alternatives to Appendix A criteria as described in the Introduction in Appendix A to Part 40. The review would cover the level of protection to the public health and safety and the environment and the level of stabilization and containment of the site. All site-specific licensing decisions based on Appendix A criteria or proposed alternatives will consider the risk to health and safety and the environment and the economic costs involved.

For license amendments, the review should focus on the changes proposed in the amendment (see Appendix A for guidance on reviewing historical aspects of site performance). Reviewers should not review previously accepted actions if they are not part of the proposed amendment, unless the review of the amendment package identifies an impact on previously accepted actions.

For changes to previously approved RPs, the licensee need only submit information pertinent to the proposed change. The licensee need not resubmit a complete RP covering all aspects of site reclamation, but should present information on the proposed changes to the previously approved plan and its updates as identified in the current NRC-accepted license. Reviewers should also analyze the inspection history and operation of the site to see if any major problems have been identified over the course of the license term that would have an effect on reclamation. The operating history of the facility is often a valuable source of information concerning the adequacy of site characterization, the acceptability of radiation protection and monitoring programs, and other data that may influence the staff's determination of compliance. Appendix A to the SRP presents guidance for review of these historical aspects of facility performance. If the changes are found to be acceptable, the license is then amended to identify the revised reclamation plan as the required design for reclamation.

License termination usually involves a confirmation that all applicable requirements have been met. This includes ensuring completion of stabilization work for the tailings consistent with the accepted reclamation plan, and a determination that the licensee has complied with all standards applicable to land structures, and ground-water cleanup. As such, the information in this review plan will be used to help make the necessary conclusions concerning license termination in three ways. First, this SRP will present guidance on how the reclamation and ground-water cleanup plans will be reviewed to determine if they are in compliance with requirements of Part 40, Appendix A. Second, the SRP will help the reviewers determine if land and structures have been decommissioned consistent with the accepted design. Information for this review is found in a construction completion report, as supplemented by NRC inspection of construction. Finally, the SRP provides guidance on what needs to be done to determine if the ground-water cleanup program has achieved its objective of restoring any contaminated ground water to appropriate standards. Compliance with these three aspects of reclamation, taken together, forms the basis for the staff's finding that the design and ground-water cleanup program meet applicable requirements, and that the design and cleanup program have been acceptably completed at the sites. Thus, the licensee has met the applicable requirements.

The staff will prepare the following reports to document the review: a technical evaluation report (TER) and an environmental assessment (EA). The provisions of 10 CFR 51.20 require preparation of an EA unless: (1) the staff finds, based on the EA, that NRC needs to prepare an environmental impact statement (EIS); (2) another Federal agency also involved in the action as a cooperating agency needs an EIS; (3) an EIS would be needed if the effects on the quality of the human environment are likely to be highly controversial; or (4) 10 CFR 51.22 categorically excludes the necessity to prepare an EA. Applications for new mills require a licensee to prepare an EIS in accordance with 10 CFR 51.20.

It is important to note that the acceptance criteria noted in this SRP are for the guidance of NMSS staff responsible for the review of applications. Review plans are not substitutes for the Commission's regulations, and compliance with a particular SRP is not required. Methods and solutions different from those set out in the SRP may be acceptable if they provide a basis for the findings requisite to the issuance or continuance of a license by NRC. Use of this SRP does not obviate the need for professional judgement; it helps assure overall completeness and uniformity of the staff's review.

GENERAL REVIEW PROCEDURE

A licensing review is not intended to be a detailed evaluation of all aspects of facility operations. Specific information about implementation of a program or construction of a design outlined in an application is obtained through the NRC review of procedures and operations done as part of the inspection function. The differences between licensing reviews and inspections are shown in the schematic that follows this Introduction (figure 1). For a new license application, the staff will review the proposed reclamation plan and ground water program for compliance with the criteria in Appendix A to Part 40. For a license renewal or an amendment to an existing license, the staff will only review proposed changes to the NRC-approved RP for compliance with criteria in Appendix A to Part 40. If the changes proposed have an adverse impact on the performance or functionality of some of the approved features at the site, then the staff will review those items for their compliance with regulations.

In the case of an amendment application concerning with confirmation of site or ground-water cleanup, or completion of construction, the reviewer will focus on ensuring that the applicable activities have been completed consistent with the RP accepted earlier. Reviewers will not revisit accepted designs or plans unless the as-completed activity shows problems, such as degradation or reconformation as documented in SECY-95-155.

Changes to existing licensed activities and conditions require the issuance of an appropriate license amendment. An application for such an amendment should describe the proposed changes in detail, and should discuss the potential environmental and health and safety impacts. Amendment requests should be reviewed using the appropriate sections of this document for guidance. Appendix A to this SRP contains guidance for examining the historical aspects of facility operations in connection with amendment reviews.

Figure 2. Schematic of Nuclear Regulatory Commission licensing and inspection process and, applicability to different license documents

The steps of the RP review are described in the paragraphs that follow.

Acceptance Review

The staff will conduct an acceptance review of a new RP or changes to a previously approved plan to determine the completeness of the information submitted. The RP will be considered acceptable for docketing if the information in it is complete, reflects an adequate reconnaissance and physical examination of the regional and site conditions, and contains appropriate analyses and design information to demonstrate that the applicable regulatory criteria will be met. Completeness of the ER will be determined using the information requirements in 10 CFR 51.45. The staff should complete the acceptance review and transmit the results to the applicant within 30 days of the receipt of the application, along with a projected schedule for the remainder of the review. In this transmittal, the staff should note any additional information needed to make the RP or ER complete. Detailed technical questions, although not required, can be included, if they are identified during the acceptance review. If the contents of the RP or ER do not clearly demonstrate compliance with applicable regulatory criteria, then the staff may decline to docket the RP and will return it to the licensee for revisions.

Detailed Review

Following completion of the acceptance review, the staff will conduct a detailed technical review of the RP. During the detailed review, if there is a need for additional information, the staff will send to the licensee a request for additional information (RAI) identifying the issue or concern, basis for the concern, and the kind of information needed to resolve the concern. After the staff receives a satisfactory response to the RAI, the detailed review will be concluded. NRC documents the results of this review and the basis for acceptance or denial of the requested licensing action in a TER, and in an EA (10 CFR 51.30) if there is a finding of no significant impact (FONSI), or in an EIS (10 CFR 50.31) if the RP is part of an application for a new mill or if one of the other requirements for an EIS have been met (10 CFR 51.20). The detailed review should evaluate the environmental, economic, and technical evidence presented by the applicant to support the ability of the proposed facility to meet applicable regulatory requirements. In the case of amendments to an existing license as a result of changes to a previously approved RP, the need for an EA will be determined on a case-by -case basis.

In determining the acceptability of any aspect of tailings reclamation, the staff will evaluate the use of alternatives to meeting the specific requirements in Part 40, Appendix A. In evaluating the use of alternatives, the staff will determine if the proposed reclamation design satisfactorily demonstrates the requisite requirements of economic benefit and equivalent protection. In this SRP, we identify alternatives that have been found to be acceptable by the staff in previous reviews. Alternatives developed by licensees need not be limited to those discussed here. Other alternatives can be proposed, as long as the economic benefit and equivalent protection can be demonstrated.

The Standard Review Plan

The SRP is written to cover a variety of site conditions and reclamation designs. Each section presents the complete procedure and acceptance criteria for all the areas of review pertinent to that section. For any given application, the staff reviewer may select and emphasize particular aspects of each SRP section as appropriate for the RP. Because of this, the staff may not carry out, in detail, all of the review steps listed in each SRP section, in the review of every RP.

I. Areas of Review

This subsection describes the scope of the review (i.e., what is being reviewed). It contains a brief description of the specific technical information and analyses in the RP that need to be reviewed by each technical reviewer.

II. Review Procedures

This subsection discusses the appropriate review technique. It is generally a step-by-step procedure that the reviewer uses to determine whether the acceptance criteria have been met.

III. Acceptance Criteria

This subsection delineates criteria that the reviewer can apply to determine the acceptability of the applicant’s compliance demonstration. The technical bases for these criteria have been derived from 10 CFR Parts 40 and 20, NRC regulatory guides, general design criteria, codes and standards, NRC branch technical positions, standard testing methods (e.g., American Society for Testing and Materials (ASTM) standards), technical papers, and other similar sources. These sources typically contain solutions and approaches previously determined by the staff to be acceptable for making compliance determinations for the specific area of review. These acceptance criteria have been defined so that staff reviewers can use consistent and well-documented approaches for review of all RPs. In the absence of well-defined acceptance criteria, the staff will rely on “professional judgment” and what is normally practiced in the profession. Licensees may take approaches to demonstrating compliance that are different from those in this SRP. However, they should recognize that, as is the case for regulatory guides, substantial staff time and effort have gone into the development of these procedures and criteria, and a corresponding amount of time and effort may be required to review and accept new or different solutions and approaches. Thus, licensee-proposed solutions and approaches to safety problems or safety-related design areas other than those described in this SRP may experience longer review times and NRC requests for more extensive supporting information. The staff is willing to consider proposals for other solutions and approaches on a generic basis, apart from a specific review, to avoid the impact of the additional review time for individual cases.

IV. Evaluation Findings

This subsection presents the staff’s general conclusions and findings that result from review of each area of the RP, as well as an identification of the applicable regulatory requirements. Conclusions and findings for a specific site and review area are dependent on the site characteristics and type of licensing action being considered. For each SRP section, a conclusion is included in the technical evaluation report/safety evaluation report or in the EA/EIS, in which results of the review are published. These documents contain a description of the review; the basis for the staff findings, including aspects of the review selected or emphasized; where the reclamation design or the licensee’s plans deviate from the criteria stated in the SRP; and the evaluation findings.

SRP Updates

The SRP will be revised and updated periodically as the need arises to clarify the content or correct errors and to incorporate modifications approved by NRC management. A revision number and publication date are printed at a lower corner of each page of the SRP. Since individual sections will be revised as needed, the revision numbers and dates may not be the same for all sections.

REFERENCES

None

1.0 GEOLOGY AND SEISMOLOGY

The reclamation plan (RP) and its supporting documents must contain sufficient regional and site-specific geologic and seismologic information related to the proposed disposal site and reclamation design, including regional and site-specific stratigraphy, structure, geomorphology, and seismology. This Standard Review Plan (SRP) establishes the requirements for staff of the U.S. Nuclear Regulatory Commission (NRC) to conduct and document the review of new RPs for mill tailings impoundments, or amendments to previously approved RPs in the areas of geology and seismology.

1.1 STRATIGRAPHIC FEATURES

1.1.1 Areas of Review

The staff shall review information presented in the RP on the regional and site-specific stratigraphy. The RPs shall describe surface and subsurface strata and the interpretation of their origin, occurrence, thickness, composition, age, and relationship. The reviewer shall coordinate the stratigraphic information with the evaluation of the site's geotechnical stability, surface water and erosion protection, and ground-water resources protection information as described in SRP Chapters 2.0, 3.0, and 4.0, respectively. The purpose of this review is to determine if there has been an acceptable characterization of site and regional stratigraphy so that sufficient information has been presented for use in the RP and design of the tailings cell.

1.1.2 Review Procedures

The reviewer shall examine the description and discussion of the regional and site-specific features to determine if a thorough evaluation of the regional and site stratigraphy has been presented.

The following specific descriptive information shall be reviewed to determine its adequacy for characterizing the regional and site-specific stratigraphic features:

(1) Description of regional stratigraphic units by rock classification and type,

(2) Distribution of regional stratigraphic units,

(3) Age relationships of regional and site-specific stratigraphic units, and

(4) Detailed site stratigraphy based on borings conducted to determine rock types and their texture, composition, distribution, and thickness.

The staff's determination of compliance shall be based in part on professional judgment, considering the complexity of the subsurface conditions at the site.

1.1.3 Acceptance Criteria

The characterization of regional and site stratigraphy will be acceptable if the information presented conforms to the following criteria:

(1) The regional and site-specific stratigraphy are described in sufficient detail to produce an adequate understanding of the site-specific subsurface characteristics, including descriptions of major stratigraphic units and their orientations, age relationships, thicknesses, and distribution.

(2) Stratigraphic units are described in sufficient detail to provide input to a geotechnical stability analysis.

(3) Descriptions of regional and site-specific stratigraphic units contain sufficient information for input to an analysis of ground water resources and the protection thereof.

(4) Regional stratigraphic information is discussed in sufficient detail to support site-specific information.

(5) Descriptions of the regional and site stratigraphy are based on published literature and site data and conform to standard geological classifications.

(6) Discussions of regional stratigraphy are adequately referenced and supported by published reports, maps, logs, and cross-sections.

(7) Site descriptions are based on field investigations and sampling to define properties of surface and subsurface materials at the site.

(8) Maps show the locations of all site explorations, such as borings, geophysical surveys, trenches, and sample locations.

Where insufficient information is presented to support interpretations and conclusions, the reviewer will request additional investigations or data gathering. The staff's determination of compliance shall be based in part on professional judgment, considering the complexity of the site conditions.

1.1.4 Evaluation Findings

If the staff's review, as described in SRP Section 1.1, results in the acceptance of the characterization of regional and site stratigraphy, the following conclusions may be presented in the technical evaluation report (TER).

> The staff has completed its review of the characterization of the regional and site stratigraphy during reclamation and decommissioning at the _______________ uranium mill facility. This review included an evaluation using the review procedures in Section 1.1.2 and the acceptance criteria outlined in Section 1.1.3 of the Title II SRP.
>
> The licensee has provided an acceptable description of the stratigraphic features by presenting a description of the site and regional stratigraphy using published information and information collected for the specific purpose of supporting determinations of geotechnical stability and ground water analyses at the site. Data gathering,

investigations, and analyses have used acceptable standards and practices. Data and interpretations are presented to allow effective incorporation into geotechnical and ground-water analyses.

1.1.5 References

None

1.2 STRUCTURAL AND TECTONIC FEATURES

1.2.1 Areas of Review

The staff shall review information presented in the RP on the regional and site-specific structural and tectonic setting. The RP shall contain a definition of surface and subsurface structural and tectonic features and an interpretation of their origin, occurrence, age, and potential impacts, if any, on the stability of the site. Review of the structural and tectonic information shall be coordinated with the evaluation of the site's geotechnical stability, surface water and erosion protection, and ground-water resources protection information as described in SRP Chapters 2.0,3.0,and 4.0, respectively. The reviewer will determine whether the information presented is sufficient to support an analysis of geologic features as they affect the facility.

1.2.2 Review Procedures

The reviewer shall examine the description and discussion of the regional and site-specific information to determine if a thorough evaluation of structural and tectonic features has been presented. This may include analyses of photogrammetric data, results of field reconnaissance and detailed mapping, review of pertinent literature, and geophysical data and studies. Features that should be considered in the review include structural features such as faults and fractures, crustal deformation, and volcanic features that may impact the site stability or ground-water conditions.

The following specific descriptive information shall be reviewed to determine its adequacy for characterizing the regional and site-specific structural features necessary to support the evaluations of reclamation system performance:

(1) Description and location of regional structural features based on published information and field reconnaissance;

(2) Description and location of site subsurface structural features from sources such as available borings, drill logs, geophysical logs and data, and existing literature;

(3) Description of any volcanic features such as flows, cones, plugs, or dikes located in the site region;

(4) Age relationships of regional and site-specific structural and tectonic features;

(5) Discussion of published literature containing interpretations of any of the information in items 1, 2, 3, and 4, above.

(6) A description of known mineral resources and recovery operations.

The staff's determination of compliance shall be based in part on professional judgment, considering the complexity of the subsurface conditions at the site.

1.2.3 Acceptance Criteria

The characterization of regional and site structural features will be acceptable if the information presented in the RP conforms to the following criteria:

(1) Descriptions of regional and site-specific structural and tectonic features are based on published literature and gathered data.

(2) Regional structural and tectonic features, particularly faults, are defined in sufficient detail to present an adequate understanding of the structural geologic conditions in the region surrounding the site that may have a likelihood of impacting the site stability or ground-water regime.

(3) Site-specific structural and tectonic features, particularly faults, are described in sufficient detail to present adequate information for an analysis of the site stability. Information presented should address the uncertainties and variability within the site area and the potential impacts on the disposal facility.

(4) The structural and tectonic province or provinces that influence the site seismicity are identified and described.

(5) The tectonic history of the pertinent province(s) is discussed in sufficient detail to support an analysis of the potential for disruption of the site by tectonic activity.

(6) Discussions are adequately referenced and are supported by maps, logs, and cross sections showing locations of all site explorations and surveys, and depicting surface and subsurface structural and tectonic features.

(7) Descriptions contain discussions of age relationships of structural and tectonic features.

Where insufficient information is presented to support interpretations and conclusions, the reviewer will request additional investigations or data gathering. The staff's determination of compliance shall be based in part on professional judgment, considering the complexity of the site conditions.

1.2.4 Evaluation Findings

If the staff's review, as described in SRP Section 1.2, results in the acceptance of the characterization of the structural and tectonic features of the region and site, the following conclusions may be presented in the TER.

> The staff has completed its review of the characterization of structural and tectonic features at the _____________ uranium mill facility. This review included an evaluation using the review procedures in Section 1.2.2 and the acceptance criteria outlined in Section 1.2.3 of the Title II SRP.

The licensee has acceptably described the regional and site-specific structural and tectonic features by presenting discussions and interpretations of data and reports pertinent to the subject area, which may have an impact on the site or tailings disposal system. Information presented includes descriptions of any faults capable of disrupting the site and any other information necessary to support an analysis of the geotechnical stability or ground-water conditions at the site. In addition, the staff concludes that the licensee has used acceptable methods of investigation and analysis to support its conclusions.

1.2.5 References

None

1.3 GEOMORPHIC FEATURES

1.3.1 Areas of Review

The staff shall review the information presented in the RP on the regional and site-specific geomorphic features. The RP shall analyze regional and local landforms to determine evidence for geomorphic processes that may impact the long-term stability of the site, including information to support an evaluation of the potential for any destructive geomorphic processes, such as mass wasting, extreme erosion, and stream encroachment. The reviewer shall coordinate the geomorphic information with the evaluation of the site's geotechnical stability and surface water and erosion protection information as described in SRP Chapters 2.0 and 5.0, respectively. The results of this review will be used to determine the acceptability of the design during operation and long-term stabilization.

1.3.2 Review Procedures

The reviewer shall examine the description and discussion of the regional and site-specific geomorphic information to determine if a thorough evaluation has been presented. Information should be detailed enough for the reviewer to make a determination regarding the geomorphic stability of the site.

The following specific descriptive information shall be reviewed to determine the acceptability of the assessment of the regional and site-specific geomorphology as it relates to geomorphic stability of the site:

(1) Description of the physiographic (geomorphic) province(s) in which the site is located, including a discussion of the distinguishing characteristics such as elevation and relief;

(2) Discussion of the active processes, such as erosion, mass wasting, and stream encroachment, within the site region and the nature and extent of those processes;

(3) Topographic maps depicting geomorphic surfaces, physiographic provinces, landforms, drainage networks, rivers, surficial geologic units, areas of subsidence, and geomorphic hazards;

(4) Aerial photographs of the site area;

(5) Discussion of the age, occurrence, and origin of geomorphic features, in particular those that may adversely affect site stability.

1.3.3 Acceptance Criteria

The characterization of regional and site geomorphic features and geomorphic stability will be acceptable if the information presented conforms to the following criteria:

(1) Descriptions of the regional and site-specific geomorphology and geomorphic processes include information sufficient to allow the reviewer to assess the nature and extent of major active processes that may modify the present-day topography of the geomorphic province(s) and the site area.

(2) The geomorphic features, particularly potential geomorphic hazards, are clearly delineated on topographic base maps of adequate scale to enable the reviewer to assess their occurrence and distribution.

(3) Descriptions are adequately referenced and are supported by published reports and maps or site data.

(4) The regional and site-specific geomorphology and geomorphic processes are described in sufficient detail to support an analysis of the geomorphic and geotechnical stability of the site.

Where insufficient information is presented to support interpretations and conclusions, the reviewer will request additional investigations or data gathering. The staff's determination of compliance shall be based in part on professional judgment, considering the complexity of the site conditions.

1.3.4 Evaluation Findings

If the staff's review, as described in SRP Section 1.3, results in the acceptance of the characterization of the geomorphic features of the region and site and provides information sufficient to support an assessment of the geomorphic stability, the following conclusions may be presented in the TER.

> The NRC has completed its review of the information concerning the characterization of geomorphic features at the ___________________uranium mill facility. This review included an evaluation using the review procedures in Section 1.3.2 and the acceptance criteria outlined in the Title II SRP.
>
> The licensee has acceptably described the geomorphic features by presenting an adequate description of regional and site geomorphology using published information and information collected for the specific purpose of supporting determinations of the stability of site. Data gathering, investigations, and analyses have used acceptable standards and practices. Data and interpretations are presented to allow effective incorporation into other site analyses.

1.3.5 References

None

1.4 SEISMICITY AND GROUND MOTION ESTIMATES

1.4.1 Areas of Review

The staff shall review information presented in the RP on the regional and site-specific seismicity. The RP shall contain an assessment of the basis for determining the vibratory ground motion (peak horizontal acceleration (PHA)) at the site from seismic events. The purpose of this review is to determine the potential for seismic events to affect the site. The reviewer will determine whether the information presented is sufficient to support an analysis of the design for the operational and closure periods.

1.4.2 Review Procedures

The reviewer shall examine the description and discussion of the regional and site-specific information to determine if a thorough evaluation of the potential for seismic activity has been presented. The information should be sufficient to enable the reviewer to determine the vibratory ground motion (PHA) at the site from seismic events.

The following specific descriptive information shall be reviewed to determine the acceptability of the characterization of the seismicity and the assessment of the stability of the site and geotechnical design:

(1) A listing of all recorded earthquakes in the tectonic province in which the site is located and in other tectonic provinces within 200 km (124 miles) of the site; This listing should contain the date of occurrence of the earthquake, its magnitude, and the location of the epicenter. Since earthquakes have at times been reported in terms of intensity at a given location, or effect on ground, structures, and people at a specific location, some of this information may have to be estimated by use of appropriate empirical relationships.

(2) Data obtained by standard photogeologic analysis and field reconnaissance of the study area and from review of the pertinent literature. Information in the form of maps, papers, or other, specific to the area or region, generated by State and Federal afencies or published in the literature;

(3) An association of epicenters or locations of highest intensity of historic earthquakes with tectonic structures, where possible. Epicenters or locations of highest intensity that cannot be reasonably identified with tectonic structures should be identified with tectonic provinces;

(4) Maps on which the locations of epicenters of historic earthquakes, associated tectonic structures, and tectonic provinces have been depicted;

(5) The applicant's proposed maximum earthquakes associated with each tectonic province or capable fault or structure;

(6) Deterministic and/or probabilistic seismic hazard analyses;

(7) Seismic design ground motion (PHA).

The staff's determination of compliance shall be based in part on professional judgment, considering the complexity of the regional and site-specific seismicity. The reviewer will focus on evaluating the maximum credible earthquake (MCE), as required by Part 40, Appendix A, Criterion 4(e), unless an alternate method of determining ground motion is presented as allowed in the Introduction to Appendix

A. One such alternative to the MCE is a probabilistic seismic hazard analysis (PSHA), which is presented in Section 1.4.3, below.

1.4.3 Acceptance Criteria

The information presented on the regional and site-specific seismicity will be acceptable if it contains sufficient detail to allow the staff to determine the vibratory ground motion (PHA) at the site caused by seismic events and to further use that determination to assess the geotechnical stability of the site. In conducting this review, the staff will consider a deterministic and/or a probabilistic seismic hazard analysis as an acceptable method for selecting the PHA for a site. An analysis of the geotechnical stability of the design proposed in the RP will be based on the resultant PHA (Chapter 2.0, "Geotechnical Stability," of this SRP).

Deterministic Analysis

For a deterministic analysis, the potential ground motion at the site from capable faults within the site region should be assessed. The term "capable fault" as used in Part 40, Appendix A, Criterion 4(e) has the same meaning as defined in Section III(g) of Appendix A to 10 CFR Part 100. Alternatively, the licensee may choose to use the term "capable tectonic source" as defined in Appendix A to Regulatory Guide 1.165 (NRC, 1997) to conduct its deterministic analysis. Capability should be determined by suitable methods, such as those outlined by Slemmons (1977) and Wells and Coppersmith (1994). Fault length versus magnitude relationships developed by Slemmons et al. (1982) or Bonilla, Mark, and Lienkaemper (1984) are appropriate for determining the maximum magnitude earthquake that may be produced by each capable fault or capable tectonic source. For each maximum magnitude earthquake, the PHA at the site should be determined using an accepted attenuation relationship between earthquake magnitude and distance. Campbell and Bozorgnia (1994) and Boore, Joyner, and Fumal (1993) offer examples of an acceptable relationship. In applying the relationship, the site-to-source distance should be the distance between the site and the closest approach of the fault. The PHA value adopted for each capable fault or tectonic source should be no less than the median value provided by the attenuation relationship. Possible soil amplification effects should be considered.

To assess potential ground motion at the site from earthquakes not associated with known tectonic structures (i.e., random or floating earthquakes), the largest floating earthquake reasonably expected within the tectonic province should be identified. In addition, the largest floating earthquakes characteristic of any adjacent tectonic provinces should be identified, if such earthquakes may cause appreciable ground motion at the site. For each of these earthquakes, the PHA at the site should be calculated as stated above. However, 15 km (9 miles) should be used as the site-to-source distance for floating earthquakes within the host tectonic province. For floating earthquakes in other tectonic provinces, the distance between the site and the closest approach of the province boundary should be used as the site-to-source distance.

The PHA for the site should be the maximum value of the PHAs determined for earthquakes from all capable faults, tectonic sources, and tectonic prvinces.

Probabilistic Analysis

A PSHA yields a curve of exceedence probability versus PHA. The 10^{-4} value represents a 1 in 10 chance of the site exceeding the PHA in a 1000-year period, which is appropriate for a 1000-year design life. The seismic hazard analysis of uranium recovery mill sites by Bernreuter, McDermott, and Wagoner (1994) contains probabilistic analyses for Title II mill sites. The study by Bernreuter et al.

(1994) is intended as a screening study; the probabilistic seismic hazard estimates are not site specific and are only calculated for random earthquakes. The use of a PSHA as an alternative to the requirements of Part 40, Appendix A, Criterion 4(e), is acceptable, as is stated in the Introduction to Appendix A, provided that it can be shown that the design proposed by the licensee will achieve a level of stabilization and containment, and a level of protection for public health and safety and the environment, which is equivalent to, to the extent practicable, or more stringent than that achieved by the requirements of Part 40, Appendix A.

The licensee may need to take into account local conditions when estimating the seismic design of the facility because PHA values are often calculated for hypothetical rock foundations. The effects of local site conditions on the peak ground acceleration PGA are reviewed in Chapter 2.0 in the SRP.

The presentation on seismotectonic stability is acceptable if sufficient information is presented to support interpretations and conclusions. If the staff should conclude that the information presented is insufficient, it will request additional information or investigations. The staff's determination of compliance shall be based, in part, on professional judgment, considering the complexity of site and seismic conditions.

1.4.4 Evaluation Findings

If the staff's review as described in SRP Section 1.4 results in the acceptance of the characterization of the seismicity of the region and site and the seismic design ground motion, the following conclusions may be presented in the TER.

> The staff has completed its review of the characterization of the seismicity at the _____________ uranium mill facility. This review included an evaluation using the review procedures in Section 1.4.2 and the acceptance criteria oulined in Section 1.4.3 of the Title II SRP.
>
> The licensee has presented information and investigations that support its conclusions about the seismic characterization of the site and the seismic design value. Information presented includes descriptions of historical earthquakes, locations of their epicenters, an analysis of the seismic hazard at the site, and the design PHA. The staff concludes that the information presented is sufficient to support an analysis of the geotechnical stability. In addition, the staff concludes that the licensee has used acceptable methods of investigation and analysis to support its conclusions.

1.4.5 References

Bernreuter, D., E. McDermott, and J. Wagoner. 1994. "Seismic Hazard Analysis of Title II Reclamation Plans." Lawrence Livermore National Laboratory.

Bonilla, M.G., R. K. Mark, and J. J. Lienkaemper. 1984. "Statistical Relations Among Earthquake Magnitude, Surface Rupture Length, and Surface Fault Displacement." *Bulletin of the Seismological Society of America,* Vol. 74, pp. 2379 - 2411.

Boore, D.M., W.B. Joyner, and T.E. Fumal. 1993. "Estimation of Response Spectra and Peak Acceleration From Western North American Earthquakes: An Interim Report." Open-File Report 93-509. U.S. Geological Survey.

Campbell, K.W., and Y. Bozorgnia. 1994. “Near Source Attenuation of Peak Horizontal Acceleration From Worldwide Accelerograms Recorded From 1975 to 1993." *Fifth U.S. National Conference on Earthquake Engineering, Chicago, Illinois.* July 10-14, 1994.

Nuclear Regulatory Commission. 1997. “Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion.” Regulatory Guide 1.165. Washington, D.C. March 1997.

Slemmons, D.B. 1977. ”State-of-the-Art for Assessing Earthquake Hazards in the United States: Report 6, Faults and Earthquake Magnitudes.” Miscellaneous paper S-73-1, U.S. Army Engineer Waterways Experiment Station, Corps of Engineers -Vicksburg, Mississippi.

Slemmons, D.B., P.O’Malley, R.A. Whitney, D.H. Chung, and D.L. Bernreuter. 1982. “Assessment of Active Faults for Maximum Credible Earthquakes of the Southern California-Northern Baja Region.” Publication No. UCID 19125 University of California, Lawrence Livermore National Laboratory.

Wells, D.L., and K.J. Coppersmith. 1994. “New Empirical Relationships Among Magnitude, Rupture Length, Rupture Width, Rupture Area, and Surface Displacement.” *Bulletin of the Seismological Society of America.* Vol. 84, pp. 974-1002.

1.5 SUMMARY OF GEOLOGY AND SEISMOLOGY EVALUATION FINDINGS

If the staff’s review as described in SRP Sections 1.1 through 1.4 results in the acceptance of the geologic and seismic characterization of the site, the following conclusion may be presented in the TER:

> On the basis of the information and analysis presented in the RP on the seismicity and seismic hazards at the _____________ uranium mill facility, the NRC staff concludes that the information is sufficient to support a determination that the following requirements of 10 CFR Part 40, Appendix A or acceptable alternatives have been met: (1) Criterion 4(e), which requires that the impoundment not be located near a capable fault on which an MCE larger than that which the impoundment could be reasonably expected to withstand might occur, or an acceptable alternate method of determination of the site’s seismic hazard, and (2) Criterion 6(1), which requires that the design of the disposal facility provide reasonable assurance of control of radiological hazards to be effective for 1000 years, to the extent reasonably achievable, and, in any case, for at least 200 years. If the PSHA is used as an alternate method of determining of the seismic hazard, the licensee must present sufficient information to support an analysis of the facility design for the operational and closure periods.

2.0 GEOTECHNICAL STABILITY

The reclamation plan (RP) and its supporting documents must contain geotechnical information, design details, and construction considerations related to the proposed disposal site and to all materials associated with the reclamation design, such as including soil and rock cover, foundation materials, contaminated materials, and other materials, for any zones (liners, filters, or capillary breaks). Standard Review Plan (SRP) Chapter 2.0 establishes the procedures for NRC staff to conduct and document the review of geotechnical stability aspects of reclamation plans for mill tailings impoundments, amendments to the approved reclamation plans, or license termination.

2.1 SITE AND URANIUM MILL TAILINGS CHARACTERISTICS

2.1.1 Areas of Review

The staff shall review information presented in the RP on the geotechnical aspects of the regional and site stratigraphy, the geotechnical characteristics of the uranium mill tailings and other materials designated for stabilization, and borrow area stratigraphy and material characteristics. "Other materials" are contaminated soil from site cleanup operations, tailings from other sites accepted for disposal at this site, and any contaminated materials from mill decommissioning activities to be disposed of at this site. This review shall cover exploration data, sampling and laboratory techniques, test results, descriptions of physical properties, and static and dynamic geotechnical engineering parameters of the materials, as well as discussions of ground-water conditions (e.g., perched, confined, or unconfined) for all critical subsurface strata at the site, including information on the fluctuations of the hydraulic head. Review of the ground-water information shall be coordinated with the review of information on ground-water resources protection, as described in SRP Chapter 4.0. Review of stratigraphic and seismologic information shall be coordinated with the review of the geology and seismology information as described in SRP Chapter 1.0. Borrow area restoration plans shall be evaluated.

2.1.2 Review Procedures

The information to be reviewed depends on whether the proposed tailings disposal is below ground in mines or excavated pits or in above ground impoundments. The reviewer should focus on the appropriateness of the site characterization for the proposed tailings disposal scheme. The reviewer shall examine the site stratigraphy and evaluation of engineering properties of the underlying materials at the site, uranium mill tailings, other materials, and borrow materials to determine if appropriate methods were properly used in characterizing the materials.

The reviewer shall examine the following specific descriptive information to determine its adequacy for characterizing the site and for supporting the evaluations of reclamation system performance:

(1) Site stratigraphy, based on borings and other investigations conducted to determine the type, location, and thickness of underlying materials;

(2) Regional and site-specific seismologic information to determine the potential for impact on the geotechnical stability of the site and site structures;

(3) Stratigraphy specifying type, location, and thickness of borrow material and other materials designated for stabilization in the tailings disposal cell;

(4) *In situ* testing programs and procedures conducted to determine the engineering properties of underlying materials at the site, borrow area material, other materials, and tailings;

(5) Sampling programs conducted to obtain laboratory samples for determination of engineering properties of borrow materials, underlying materials at the site, other materials, and tailings;

(6) Laboratory testing used to determine the engineering properties of borrow materials, underlying materials at the site, other materials, and tailings;

(6) Physical and engineering properties of borrow materials, underlying materials at the site, other materials, and tailings; and

(8) Records of historical ground water-level fluctuations at the site.

The reviewer shall evaluate methods used to characterize the site to ensure that they comply with generally accepted standards, such as American Society for Testing and Materials (ASTM, 1977) and are commonly used in the geotechnical engineering profession. Areas to be examined in this respect include the *in situ* and laboratory testing programs, sampling techniques, and analyses for determining the physical and engineering properties of materials at the site. Field investigations and laboratory testing procedures not commonly used in the geotechnical engineering profession will be reviewed in detail.

The staff's determination of compliance shall be based in part on professional judgment, considering the complexity of the site subsurface conditions.

2.1.3 Acceptance Criteria

The site characterization information constitutes part of the input data needed for analysis and design of the tailings impoundment facility. The site characterization will be acceptable if it provides the needed input for the design and analysis of the disposal facility and meets the following criteria:

(1) The site stratigraphy is described in sufficient detail to provide an understanding of the site-specific subsurface features, including structural features and other characteristics of underlying soil and rock.

(2) Information on regional and local faults and seismicity, as obtained from field data, published literature, and historical records, is presented in sufficient detail to effectively incorporate that information into a geotechnical stability analyses. (Note: This aspect of the review shall be coordinated with the geology and seismology review performed in accordance with SRP Chapter 1.)

(3) Sampling scope and techniques ensure that samples are representative of the range of *in situ* soil conditions, taking into consideration variability and uncertainties in such conditions within the site.

(4) For all soils that might be unstable because of their physical or chemical properties, locations and dimensions are identified and the properties have been documented.

(5) Investigations (including laboratory and field testing) are conducted using appropriate standards published by the ASTM or the International Society for Rock Mechanics (ISRM) and are sufficient to establish the static and dynamic engineering parameters of borrow materials, other materials, tailings, and underlying soil and rock materials at the site (NRC, 1978, 1979).

(6) A detailed discussion of laboratory sample preparation techniques is presented, when standard procedures are not used.

For critical laboratory tests, such details are given as how saturation of the sample was determined and maintained during testing, or how the pore pressures changed. A detailed and quantitative discussion of the criteria used to verify that the samples were properly taken and tested in sufficient number to define the critical soil parameters for the site is presented. In the case of tailings material (for example, license amendment reviews), the evaluations of its strength and settlement characteristics are presented in detail.

(7) Parameter values are presented to enable evaluation of properties of mill tailings, borrow materials, other materials, and underlying soil and rock, including the following:

(a) Compressibility and rate of consolidation;
(b) Shear strength, including, for sensitive soils, possible loss of shear strength resulting from strain-softening;
(c) Liquefaction potential;
(d) Permeability;
(e) Dispersion characteristics;
(f) Swelling and shrinkage;
(g) Long-term moisture content for radon barrier material; and
(h) Cover cracking.

(8) Soil stratigraphy and relevant parameters that are used in the geotechnical evaluations (settlement, stability, liquefaction potential, etc.) are discussed in detail.

(9) Records of historical ground water-level fluctuations at the site as obtained from monitoring local wells and springs and/or by analysis of piezometer and permeability data from tests conducted at the site are presented in sufficient detail to effectively incorporate the information into geotechnical stability analyses. (Note: This aspect of the review shall be coordinated with the hydrogeologic characterization review performed according to SRP Chapter 4.0).

The information should be sufficient to provide the required input for the design of the facility and to enable the reviewer to assess compliance with the regulatory requirements, such as site features contributing to waste isolation; preferred mode of disposal being below grade; facility not located near an active fault to mitigate the impact of an earthquake on the facility; and the design providing reasonable assurance of control of radiological hazards to be effective for 1000 years to the extent reasonably achievable, and in any case for at least 200 years.

2.1.4 Evaluation Findings

If the staff's review as described in SRP Section 2.1 results in the acceptance of the characterization of the site and uranium mill tailings sufficient to support a conclusion regarding the geotechnical stability of the site, the following conclusions may be presented in the TER:

> The staff has completed its review of the site stratigraphy and uranium mill tailings at the _____________ uranium mill facility. This review included an evaluation using the review procedures in Section 2.1.2 and the acceptance criteria outlined in Section 2.1.3 of the Title II SRP.
>
> The licensee has acceptably described the geotechnical characteristics of the site and uranium mill tailings based on sampling techniques that are acceptable, and will ensure that a representative range of *in situ* soil conditions will be examined. Unstable soils have been identified. Investigations and analyses have used acceptable standards and practices. Laboratory sample preparation and testing techniques are appropriately described and include: (1) compressibility and rate of consolidation; (2) shear strength; (3) liquefaction potential; (4) permeability; (5) dispersion characteristics; (6) swelling and shrinkage; and (7) physical properties. Records of historic ground water-level fluctuations are presented to allow effective incorporation into geotechnical stability analyses.
>
> On the basis of the information presented in the application and the detailed review conducted of the characteristics of the site and uranium mill tailings at the _____________ uranium mill facility, the NRC staff concludes that the characterization of the site and uranium mill tailings and associated conceptual and numerical models provide an acceptable input, which along with other information such as results of design analysis etc., will enable the staff to make a finding on the demonstration of compliance with the following criteria in Appendix A to 10 CFR Part 40: (1) Criterion 1, which relates to the site features that contribute to the permanent waste isolation characteristics of the site; (2) Criterion 3, which discusses the primary option for disposal of tailings below grade is mines or excavated pits (if applicable for the site); (3) Criterion 4(e) which requires that the impoundment not be located near a capable fault on which an maximum credible earthquake (MCE), larger than one that the impoundment could reasonably be expected to withstand, might occur; (4) Criterion 5(G)(2), relating to the permeability characteristics of the site; and (5) Criterion 6(1), relating to providing reasonable assurance of control of radiological hazards to be effective for 1000 years to the extent reasonably achievable, and in any case for at least 200 years.

2.1.5 References

American Society for Testing and Materials (ASTM) Standards:

D 420, "Guide for Investigating and Sampling Soil and Rock."

D 421, "Practice for Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants."

D 422, "Method for Particle-Size Analysis of Soils."

D 653, "Terminology Relating to Soil, Rock, and Contained Fluids."

D 854, "Test Method for Specific Gravity of Soils."

D 1140, “Test Method for Amount of Material in Soils Finer Than the No. 200 Sieve.”

D 1452, “Practice for Soil Investigation and Sampling by Auger Borings.”

D 1586, “Method for Penetration Test and Split-Barrel Sampling of Soils.”

D 1587, “Practice for Thin-Walled Tube Sampling of Soils.”

D 2113, “Practice for Diamond Core Drilling for Site Investigation.”

D 2166, “Test Method for Unconfined Compressive Strength of Cohesive Soil.”

D 2216, “Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock and Soil-Aggregate Mixtures.”

D 2217, “Practice for Wet Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants.”

D 2487, “Test Method for Classification of Soils for Engineering Purposes.”

D 2488, “Practice for Description and Identification of Soils (Visual-Manual Procedure).”

D 2573, “Test Method for Field Vane Shear Test in Cohesive Soils.”

D 3441, “Method for Deep, Quasi-Static, Cone and Friction-Cone Penetration Tests of Soil.”

D 3550, “Practice for Ring-Lined Barrel Sampling of Soils.”

D 4221, “Test Method for Dispersive Characteristics of Clay Soil by Double Hydrometer.”

D 4318, “Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.”

D 4647, “Test Method for Identification and Classification of Dispersive Clay Soils by the Pinhole Test.”

D 4750, “Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well).”

Nuclear Regulatory Commission. 1978. "Laboratory Investigations of Soils for Engineering Analysis and Design of Nuclear Power Plants," Regulatory Guide 1.138. Washington, DC. April 1978.

Nuclear Regulatory Commission. 1979. "Site Investigations for Foundations of Nuclear Power Plants," Regulatory Guide 1.132, Revision 1. Washington, DC March, 1979.

2.2 SLOPE STABILITY

2.2.1 Areas of Review

The staff shall examine exploration data, test results, slope characterization data, design details, and static and dynamic analyses related to the stability of all natural and manmade earth and rock slopes whose failure, under any of the conditions to which they could be exposed throughout the period of regulatory interest, could adversely affect the integrity of the reclamation actions. This review shall also include examination of static and dynamic materials properties, test and design methods, pore pressures within and beneath the embankment, and the design seismic coefficient. Information on the design seismic event should be obtained from results of the review completed using SRP Chapter 1.0. The review will focus on (1) the design of the impoundment during operation when a large volume of tailings liquor would be present and (2) its stability over the long term.

2.2.2 Review Procedures

The reviewer shall examine data gathered from site investigations, such as borings: maps, laboratory and field tests, soil profiles, site plans, results of seismic investigations, permeability tests, and static, dynamic, or pseudostatic stability analyses, to determine whether the assumptions and analyses used in the reclamation plan (RP) are conservative. The degree of conservatism required depends on the type of analysis used, the variability and uncertainty in the values of the parameters considered in the slope stability analysis, the number of borings, the sampling program, the extent of the laboratory testing program, and the resultant safety factor. For instances in which safety factors are low, the reviewer shall ensure that reasonable ranges of soil properties have been considered. Other factors, such as flood conditions, pore pressure effects, possible erosion of soils, and seismic amplification effects, shall be conservatively assessed. The design criteria and analyses shall be reviewed to ascertain that the techniques employed are appropriate and represent commonly accepted methods (e.g., Army Corps of Engineers, 1970b).

The reviewer shall examine the spatial variability of the measured properties to ensure that it has been adequately defined. The reviewer shall also examine slope characterization data to ensure that nearby slopes, the failure of which could adversely affect the stability of the reclamation action, have been properly characterized.

The reviewer shall determine whether the static and dynamic stability analyses demonstrate that there is an adequate factor of safety against failure.

The reviewer shall examine the slope stability analysis to determine that an appropriately conservative approach has been used and that adverse conditions to which the slope might be subjected have been considered. The reviewer shall confirm that the static analyses include calculations using appropriate assumptions and methods to assess the following:

(1) Uncertainties and variations in the shape of the slope, the boundaries and parameters of the several types of soils within the slope, the forces acting on the slope, and the pore pressures acting within and beneath the slope;

(2) The failure surface corresponding to the lowest factor of safety; and

(3) The effect of the assumptions inherent in the method of analysis used.

The reviewer shall ensure that the analysis is conservative and that possible failure modes have been considered, including evaluation of the effect of the MCE, or the appropriate design criteria found acceptable in SRP Section 1.4.

The reviewer shall be aware that no single method of analysis is applicable for all stability assessments. Therefore, no single method of analysis is recommended. If the staff review indicates that questionable assumptions have been made or that nonstandard or inappropriate methods of analysis have been used, the staff may model the slope in a manner consistent with the data and perform an independent analysis.

The reviewer shall verify that disposal cell slopes will be relatively flat, after final stabilization, to minimize the potential for erosion and to provide a conservative factor of safety. In evaluating the slope, the reviewer will focus on determining if the slopes are 5h:1v as required by 10 CFR, Part 40, Appendix A, Criterion 4(c). If slopes steeper than 5h:1v are proposed, the reviewer must evaluate these steeper slopes as an alternative to the requirements of Criterion 4(c). In conducting a review of steeper slopes, the reviewer must evaluate the acceptability of the steeper slope using the applicable criteria in this SRP as well as determine if there is an acceptable economic basis and an equivalent level of protection available to justify an alternative to Part 40, Appendix A, Criterion 4(c). The reviewer shall verify that a properly designed, fully self-sustaining vegetative cover can be placed over the tailings pile, primarily to reduce the wind and water erosion to negligible levels. If a vegetative cover is not suitable for the site conditions, the reviewer shall verify that an appropriate rock cover has been provided. This verification shall be coordinated with the review of SRP Chapter 3.0.

Because dams at operating facilities, or dams that continue to hold water after the cessation of operations, are also subject to the National Dam Safety Program Act of 1996, the reviewer will need to determine if the dam is classified as a structure with low hazard potential or high hazard potential. If the dam is classified as high hazard, the reviewer will also need to evaluate the emergency action plan (EAP) for the facility.

2.2.3 Acceptance Criteria

The analysis of slope stability will be acceptable if it meets the following criteria:

(1) Slope characteristics are properly evaluated.

(a) Cross-sections and profiles of natural and cut slopes whose instability would directly or indirectly affect the control of residual radioactive materials are presented in sufficient number and detail to enable the reviewer to select the cross-sections for detailed stability evaluation.

(b) Slope steepness is a minimum of five horizontal units (5h) to one vertical unit (1v) or less. The use of slopes steeper than 5h:1v is considered an alternative to the requirements in 10 CFR, Part 40, Appendix A, Criterion 4(c). When slopes steeper than 5h:1v are proposed, a technical justification shall be offered as to why a 5h:1v or flatter slope cannot be constructed. Appropriate compensating factors and conditions are incorporated in the slope design for assuring long-term stability. In addition, the application must contain an evaluation showing the economic benefit of slopes steeper than 5h:1v as well as a demonstration of equivalent protection.

(c) Locations selected for slope stability analysis are determined considering the location of maximum slope angle, slope height, weak foundation, piezometric level(s), the extent of rock mass fracturing (for an excavated slope in rock), and the potential for local erosion.

(2) An appropriate design static analysis is presented. For static loads, the static analysis contains calculations with appropriate assumptions and methods of analysis (NRC, 1977) and considers the following factors:

(a) The uncertainties and variability in the shape of the slope, the boundaries and parameters of the several types of soils and rocks within the slope, the material properties of soil and rock within and beneath the slope, the forces acting on the slope, and the pore pressures acting within and beneath the slope;

(b) Appropriate failure modes during and after construction and the failure surface corresponding to the lowest factor of safety. (The analysis takes into account the failure surfaces within the slopes, including any possible through the foundation.);

(c) The effect of the assumptions inherent in the method of analysis;

Adverse conditions such as high water levels from severe rain and the probable maximum flood;

(e) The effects of toe erosion, incision at the base of the slope, and other deleterious effects of surface runoff; and

(f) Minimum acceptable values of safety factors for slope stability analysis given in NRC Regulatory Guide 3.11 (NRC, 1977).

(3) Appropriate dynamic and pseudostatic analyses are presented to include the following considerations:

(a) For dynamic loads, the dynamic or pseudostatic analysis contains calculations with appropriate assumptions and methods (NRC, 1977; Seed, 1967; Lowe, 1967; Department of the Navy, 1982a,b,c; Army Corps of Engineers, 1970a,b, 1971, 1972; Bureau of Reclamation, 1968).

(b) Pseudostatic analysis is acceptable in lieu of dynamic analysis if the strength parameters used in the analysis are conservative, the materials are not subject to significant loss of strength and development of high pore pressures under dynamic loads, the design seismic coefficient is 0.20 or less, and the resulting minimum factor of safety suggests an adequate margin, as provided in NRC Regulatory Guide 3.11 (NRC, 1977).

The reviewer shall also determine, for pseudostatic analysis of slopes subjected to earthquake loads, that an assumption is made that the earthquake imparts an additional horizontal force acting in the direction of the potential failure (Army Corps of Engineers, 1970b, 1977; Goodman, 1989). The critical failure surface obtained in the static analysis is used in this analysis with the added driving force. Minimum acceptable values for safety factors of slope stability analysis are given in Regulatory Guide 3.11 (NRC, 1977).

(c) An appropriate analytical method has been used. A number of different methods of analysis are available (e.g., slip circle method, method of slices, and wedge analysis) with several variants of each (Lambe and Whitman, 1979; Army Corps of Engineers, 1970b; NRC, 1977; Bromhead, 1992). Limit-equilibrium analysis methods do not provide information regarding the variation of strain within the slope and along the slip surface. Consequently, there is no assurance that the peak strength values used in the analysis can be mobilized simultaneously along the entire slip surface unless the material shows ductile behavior (Duncan, 1992). Residual strength values should be evaluated if mobilized shear strength at some points is less than the peak strength. The reviewer should ensure that appropriate conservatism has been incorporated in the analysis using the limit equilibrium methods. The limit equilibrium analysis methodologies may be substituted with other techniques, such as finite element or finite difference methods. If any important interaction effects cannot be included in an analysis, the reviewer must determine that such effects have been treated in an approximate but conservative fashion. The engineering judgment of the reviewer must be used in assessing the adequacy of the resulting safety factors (NRC, 1983a,b).

(d) The assessment of the dynamic stability considers the MCE and the potential site amplification of ground motions. The dynamic analysis has accounted for the effect of dynamic stresses of the MCE on soil strength parameters. The potential for liquefaction of the soil shall be reviewed using the procedure in SRP Section 2.4. As in a static analysis, the parameters such as geometry, soil strength, and hydrodynamic and pore pressure forces are varied in the analysis to show that there is an adequate margin of safety.

(e) The reclamation plan may include an optional dynamic analysis, following the procedures suggested by Newmark (1965), Seed and Bonaparte (1992), and others, to show that the possible permanent deformation sustained in the slope from the MCE will not damage the disposal cell to such an extent that the effectiveness of the disposal cell is significantly reduced. The reviewer should verify that the yield acceleration or pseudostatic horizontal yield coefficient necessary to reduce the factor of safety against slippage of a potential sliding mass to 1.0 in a "Newmark-type" analysis has been adequately estimated (Seed and Bonaparte, 1992).

(f) Seismically induced displacement is calculated and documented. There is no universally accepted magnitude of seismically induced displacement for determining acceptable performance of the disposal cell (Seed and Bonaparte, 1992; Goodman and Seed, 1966). Surveys of five major geotechnical consulting firms by Seed and Bonaparte (1992) indicate that the acceptable displacement is from 15 to 30 cm (6 to 12 inches) for tailings piles. The reviewer shall ensure that this criterion is also augmented by provisions for periodic maintenance of the slope(s).

(g) The following additional items are included in the analyses:

(i) Selection of the appropriate design-level seismic events and/or strong ground motion accelerations;

(ii) Evaluation of the influence of local site conditions on the ground motions associated with a design-level event;

(iii) Evaluation of the dynamic response of the waste fill (tailings), embankments, and foundation system, especially the effect of cyclic motion of an earthquake on soil strength properties, to verify the potential for liquefaction. Where there is potential for liquefaction, changes in pore pressure from cyclic loading are considered in the analysis to assess not only the potential for liquefaction but also the effect of pore pressure increase on the stress-strain characteristics of the soil and the post-earthquake stability of the slopes. Evaluations of dynamic properties and shear strengths for the tailings, underlying foundation material, radon barrier cover, and base liner system are based on representative materials properties obtained through appropriate field and laboratory tests (NRC, 1978, 1979); and

(iv) Evaluation of overall seismic stability, using pseudostatic analysis, with appropriate design seismic coefficient, or dynamic analysis, as appropriate (Army Corps of Engineers, 1977; NRC, 1977). The design seismic coefficient to be used in the pseudostatic analysis is either 67 percent of the peak acceleration of the MCE at the foundation level of the tailings pile or 0.10, whichever is greater. Alternatively, a dynamic analysis following Newmark (1965) can be carried out to establish that the permanent deformation of the disposal cell from the MCE will not be detrimental to the disposal cell. If the design seismic coefficient is greater than 0.20, then the dynamic stability investigation (Newmark, 1965) should be augmented by other appropriate methods (i.e., finite element method), depending on specific site conditions.

(4) Provision is made to establish a vegetative cover, or other erosion prevention, to include the following considerations:

(a) The vegetative cover and its primary functions are described in detail.

This determination shall be made with respect to any effect the vegetative cover may have on reducing slope erosion and should be coordinated with the reviewer of SRP Chapter 3.

If strength enhancement from the vegetative cover is taken into account, the methodology should be appropriate (Wu, 1984).

(b) In arid and semi-arid regions, where a vegetative cover is deemed not self-sustaining, a rock cover is employed on slopes of the mill tailings. If credit is taken for strength enhancement from rock cover, the reviewer should confirm that appropriate methodology has been presented.

The design of a rock cover, where a self-sustaining vegetative cover is not practical, is based on standard engineering practice. SRP Chapter 3 discusses this item in detail.

(5) The dam meets the requirements of the dam safety program if the application demonstrates that the following:

(a) The dam is correctly categorized as a low hazard potential or a high hazard potential structure using the definition of the U.S. Federal Emergency Management Agency (FEMA); and

(b) If the dam is ranked as a high hazard potential, an acceptable EAP consistent with the FEMA guide (FEMA, 1998) has been developed.

(6) The use of steeper slopes as an alternative to the requirements in 10 CFR, Part 40, Appendix A, will be found acceptable if the following are met:

(a) Achieve an equivalent level of stabilization and containment of the site concerned and protection of public health, safety, and environment; and

(b) Demonstrate a site-specific need for the alternate slopes and an economic benefit.

2.2.4 Evaluation Findings

If the staff's review as described in SRP Section 2.2 results in the acceptance of the slope stability, the following conclusions may be presented in the TER:

> The staff has completed its review of the slope stability at the ____________ uranium mill facility. This review included an evaluation using the review procedures in Section 2.2.2 and the acceptance criteria outlined in Section 2.2.3 of the Title II SRP.
>
> The licensee has acceptably described the slope stability evaluation by (1) providing cross-sections and profiles of natural and cut slopes in sufficient detail and number to represent significant slope and foundation conditions; (2) placing tailings below grade or in demonstrably safe above-grade disposal facilities; (3) ensuring that slope steepnesses are five horizontal (5h) to one vertical (1v) or less or by providing technical justification for a different slope ratio; (4) providing measurements of static and dynamic properties of soil and rock using standards such as those established by the ASTM, ISRM, NRC, or U.S. Army Corps of Engineers; (5) selecting locations for slope stability analyses while considering the location of maximum slope angle, slope height, weak foundation, the extent of rock mass fracturing, and the potential for local erosion; and (6) describing vegetative cover and its primary functions in detail. Where the licensee has proposed use of steeper slopes as an alternative to the requirements of 10 CFR, Part 40, Appendix A, Criterion 4(c), the staff has evaluated the licensee's demonstration that steeper slopes would result in economic savings and also ensure the long-term stabilization of the tailings with a level of protection equivalent to that required in 10 CFR Part 40, Appendix A, Criterion 4(c). Therefore, the use of steeper slopes complies with the alternatives requirement in 10 CFR Part 40, Appendix A.
>
> The static loads analysis is acceptable and includes (1) appropriate uncertainties and variabilities in important rock/soils parameters; (2) consideration of appropriate failure modes; (3) a discussion of the effect of the assumptions inherent in the method of analysis used; (4) consideration of adverse conditions, including flooding, with appropriate safety factors; and (5) the effects of toe erosion, incision of the base of the slope, and other deleterious effects of surface runoff.

The dynamic and pseudostatic analyses are acceptable and include (1) calculations with appropriate assumptions and methods; (2) treatment of important interaction effects in a conservative fashion; (3) an accounting of the dynamic stresses of the MCE on soil strength parameters; (4) for pseudostatic analyses of slopes subjected to earthquake loads, consideration of the added driving horizontal force acting in the direction of a potential failure; (5) determination that possible permanent deformation sustained in the slope from MCE will not damage the effectiveness of the disposal cell; (6) determination that the magnitude of seismically induced displacement does not exceed 15 to 30 cm. (6 to 12 inches); (7) a selection of appropriate design-level seismic events or strong ground motion accelerations; (8) evaluations of local site conditions; (9) evaluations of the potential for liquefaction and the effect of pore pressure increase on the stress-strain characteristics of the soil and post-earthquake stability of the slopes; (10) evaluations of the dynamic properties and shear strength of the tailings, underlying foundation, radon barrier cover, and base liner system; and (11) design of a self-sustaining vegetative or rock cover that is consistent with commonly accepted engineering practice.

On the basis of the information presented in the application and the detailed review conducted of the slope stability at the _____________ uranium mill facility, the NRC staff has concludes that the slope stability and associated conceptual and numerical models pertaining to design in the RP provide an acceptable input to demonstration of compliance with the following criteria in 10 CFR Part 40, Appendix A: Criterion 4(c), which provides requirements for the long-term stability of the embankment and cover slopes for tailings; Criterion 4(d), which requires establishment of a self-sustaining vegetative cover or employment of a rock cover to reduce wind and water erosion to negligible levels, that individual rock fragments are suited for the job, and that the impoundment surfaces are contoured to avoid concentrated surface runoff or abrupt changes in slope gradient; Criterion 4(e), which requires that the impoundment not be located near a capable fault on which an MCE larger than that which the impoundment could reasonably be expected to withstand might occur; Criterion 5(A)(5), which requires the structural integrity of slopes (dikes) to prevent massive failure of the dikes; and Criterion 6(1), relating to providing reasonable assurance of control of radiological hazards to be effective for 1,000 years to the extent reasonably achievable, and in any case for at least 200 years.

2.2.5 References

American Society for Testing and Materials (ASTM) Standards:

D 2850, “Test Method for Unconsolidated, Undrained Compressive Strength of Cohesive Soils in Triaxial Compression.”

D 3080, “Method for Direct Shear Test of Soils Under Consolidated Drained Conditions.”

D 4767, “Test Method for Consolidated-Undrained Triaxial Compression Test on Cohesive Soils.”

Army Corps of Engineers, 1970a. *Laboratory Soil Testing.* Engineering Manual EM1110-2-1906. November 1970.

Army Corps of Engineers. 1970b. *Engineering and Design Stability of Earth and Rock Fill Dams*. Engineering Manual EM1110-2-1902. Office of the Chief of Engineers, Department of the Army 1970.

Army Corps of Engineers. 1971. *Instrumentation of Earth and Rockfill Dams.* Engineering Manual EM1110-2-1908, Part 1 and 2. August and November 1971.

Army Corps of Engineers. 1972. *Soil Sampling,* Engineering Manual EM1110-2-1907. March 1972.

Army Corps of Engineers. 1977. Earthquake Design and Analysis for Corps of Engineer Dams. ER1110-2-1806. April 1977.

Bromhead, E.N. 1992. *The Stability of Slopes.* London: Blackie Academic & Professional. 1992.

Bureau of Reclamation. 1968. *Earth Manual.* First Edition. Washington, D.C.: U.S. Department of the Interior.

Department of the Navy. 1982a. *Soil Mechanics.* NAVFAC DM 7.1. May 1982.

Department of the Navy, 1982b. Foundations and Earth Structures. NAVFAC DM 7.2. May 1982.

Department of the Navy. 1982c. *Soil Dynamics, Deep Stabilization, and Special Geotechnical Construction,* NAVFAC DM 7.3. May 1982.

Duncan, J.M. 1992, "State-of-the-Art: Static Stability and Deformation Analysis. Stability and Performance of Slopes and Embankments-II, Volume 1. *Proceedings of a Specialty Conference.* R.B. Seed and R.W. Boulanger, eds. Geotechnical Special Publication No. 31. New York, American Society of Civil Engineers.

Goodman, R.E. 1989. *Introduction to Rock Mechanics.* 2nd edition. New York: John Wiley & Sons.

Goodman, R.E., and H.B. Seed. 1966. "Earthquake-Induced Displacements in Sand Embankments." *ASCE Journal of the Soil Mechanics and Foundations Division* 92(SM2). March 1966.

Lambe, T.W., and R.V. Whitman, 1979, *Soil Mechanics, SI Version,* New York: John Wiley & Sons,1979.

Lowe, J., III., 1967, "Stability Analysis of Embankments," ASCE Journal of the Soil Mechanics and Foundations Division 93(SM4).

Newmark, N.M. 1965, "Effects of Earthquakes on Dams and Embankments." Geotechnique. June 1965.

Nuclear Regulatory Commission. 1977. "Design, Construction, and Inspection of Embankment Retention Systems for Uranium Mills." Regulatory Guide 3.11, Revision 2. December 1977.

Nuclear Regulatory Commission. 1978. "Laboratory Investigations of Soils for Engineering Analysis and Design of Nuclear Power Plants." Regulatory Guide 1.138, April 1978.

Nuclear Regulatory Commission. 1979. "Site Investigations for Foundations of Nuclear Power Plants," Regulatory Guide 1.132, Revision 1, March 1979.

Nuclear Regulatory Commissio. 1983a. *Guidance for Disposal of Uranium Mill Tailings: Long-Term Stabilization of Earthen Cover Materials.* NUREG/CR-3199.

Nuclear Regulatory Commission. 1983b. *Design Considerations for Long-Term Stabilization of Uranium Mill Tailings Impoundments,* NUREG/CR-3397.

Seed, H.B., 1967, "Slope Stability During Earthquakes," *ASCE Journal of the Soil Mechanics and Foundations Division,* 93(SM4).

Seed R.B., and R. Bonaparte, 1992, "Seismic Analysis and Design of Lined Waste Fills: Current Practice. Stability and Performance of Slopes and Embankments--II," Volume 1, *Proceedings of a Specialty Conference,* R.B. Seed and R. W. Boulanger, eds. Geotechnical Special Publication No. 31. New York: American Society of Civil Engineers.

Wu, T.H., 1984, *Effect of Vegetation on Slope Stability,* "Soil Reinforcement and Moisture Effects on Slope Stability," Transportation Research Record 965, Transportation Research Board, National Research Council.

2.3 SETTLEMENT

2.3.1 Areas of Review

The staff shall review the methods and results of testing and analyses conducted to estimate deformation of subsurface materials and uranium mill tailings. This shall include examination of material properties and thicknesses of compressible materials, factors used in stress calculations, calculated pore pressures within and beneath the embankment, resulting total and differential settlement of the tailings surface under both static and seismic conditions, and the effects of such settlements on the radon barrier layer of the cover of the disposal cell and erosion protection layer. Liquefaction and associated settlement are addressed in SRP Section 2.4. One of the purposes of this review is to determine if the licensee has an acceptable method for determining if tailings consolidation is sufficient to allow the placement of a radon barrier.

2.3.2 Review Procedure

The reviewer shall examine the assessments of the magnitudes and distributions of settlement of the disposal cell and the analyses of the potential for cracking of the radon barrier from tensile strains in order to determine the adequacy of the design.

The reviewer shall confirm that clay layers and slime in the tailings pile and foundations have been considered in the assessment of both immediate and long-term settlement.

In reviewing the assessment of settlements, the reviewer shall give particular attention to the identification and thicknesses of compressible soil layers within the tailings and in the foundation. Settlement should be calculated at several locations within the disposal cell to enable a determination of the overall settlement pattern of the disposal cell cover. The locations for settlement calculations should be selected considering the presence of sand/slime tailings and foundation materials. The tailings are expected to be a hydraulically placed material comprising of interspersed sand and slime tailings. The following specific items shall be reviewed to determine the acceptability of the assessment of the magnitudes and distribution of settlement:

(1) The analysis of immediate settlement of tailings surfaces, considering rebound from excavation and settlement from instantaneous compression of underlying materials and the tailings pile. The computation of incremental tailings loading and the width of the loaded area, as well as the determination of the undrained modulus and Poisson's ratio shall be examined. Calculations of the settlement of hydraulically placed tailings shall be examined.

(2) The analysis of consolidation settlement from delayed compression (caused by pore-pressure dissipation) of underlying materials and the tailings pile.

The calculation of settlement shall be reviewed to ensure that each compressible soil layer within or underneath the tailings pile is considered and is assigned proper thickness and that the appropriate level of stress change is applied at the mid-depth of the soil layer.

(3) The estimate of the time at which the primary consolidation settlement of the tailings will be essentially complete. Generally, the radon barrier and disposal cell cover may be placed only after the settlement of tailings is essentially complete.

(4) The analysis of secondary settlement from long-term creep.

(5) The distribution of settlement magnitudes for assessment of differential settlement.

(6) Evaluation of the potential for cracking of the radon barrier layer as result of long-term settlement of the cover.

2.3.3 Acceptance Criteria

The analysis of tailings settlement will be acceptable if it meets the following criteria:

(1) Computation of immediate settlement follows the procedure recommended in NAVFAC DM-7.1 (Department of the Navy, 1982). If a different procedure is used, the basis for the procedure is adequately explained.

The procedure recommended in NAVFAC DM-7.1 (Department of the Navy, 1982) for calculation of immediate settlement is adequate if applied incrementally to account for different stages of tailings emplacement. If this method is used, the reviewer shall verify that the computation of incremental tailings loading and the width of the loaded area, as well as the determination of the undrained modulus and Poisson's ratio, have been computed and documented.

Settlement of tailings arises from compression of soil layers within the disposal cell and in the underlying materials. Because compression of sands occurs rapidly, compression of sand layers in the disposal cell and foundations must be considered in the assessment of immediate settlement. However, the contribution of immediate settlement to consolidation settlement cannot be ignored. Clay layers and slime undergo instantaneous elastic compression controlled by their undrained stiffness as well as long-term inelastic compression controlled by the processes of consolidation and creep (NRC, 1983a).

(2) Each of the following is appropriately considered in calculating stress increments for assessment of consolidation settlement:

(a) Decrease in overburden pressure from excavation,
(b) Increase in overburden pressure from tailings emplacement,
(c) Excess pore-pressure generated within the disposal cell,
(d) Changes in ground-water levels from dewatering of the tailings, and
(e) Any change in ground-water levels from the reclamation action.

(3) Material properties and thicknesses of compressible soil layers used in stress change and volume change calculations for assessment of consolidation settlement are representative of *in situ* conditions at the site.

(4) Material properties and thicknesses of embankment zones used in stress change and volume change calculations are consistent with as-built conditions of the disposal cell.

(5) Values of pore pressure within and beneath the disposal cell used in settlement analyses are consistent with initial and post-construction hydrologic conditions at the site.

(6) Methods used for settlement analyses are appropriate for the disposal cell and soil conditions at the site. Contributions to settlement by drainage of mill tailings and by consolidation/compression of slimes and sands are considered. Both instantaneous and time-dependent components of total and differential settlements are appropriately considered in the analyses (NRC, 1983a,b,c).

The procedure recommended in NAVFAC DM-7.1 (Department of the Navy, 1982) for calculation of secondary compression is adequate.

(7) The disposal cell is divided into appropriate zones depending on the field conditions for assessment of differential settlement, and appropriate settlement magnitudes are calculated and assigned to each zone.

(8) Results of settlement analyses are properly documented and are related to assessment of overall behavior of the reclaimed pile.

(9) An adequate analysis of the potential for development of cracks in the radon/infiltration barrier as a result of differential settlements is provided (Lee and Shen, 1969).

2.3.4 Evaluation Findings

If the staff's review, as described in SRP Section 2.3, shows that the settlement has no impact on the integrity and functionality of the radon barrier and disposal cell cover, then the following conclusions can be presented in the TER. If the settlement impacts the cell cover integrity, then the licensee will be required to revise the design to ensure the functionality of the cell cover before a TER can be prepared.

> The staff has competed its review of the settlement at the _____________ uranium mill facility. This review included an evaluation using the review procedures in Section 2.3.2 and the acceptance criteria outlined in Section 2.3.3 of the Title II SRP.
>
> The licensee has acceptably described settlement by presenting computations following the procedure recommended in NAVFAC DM-7.1 (Department of the Navy, 1982) or by explaining the technical merit for an alternative procedure. Material properties, thickness, and load increments used to calculate settlement are representative of site conditions. The applicant has acceptably considered each of the following: (1) decrease in overburden pressure from excavation; (2) increase in overburden pressure from emplaced tailings; (3) excess pore-pressure generated within the tailings disposal cell; (4) changes in ground-water levels from dewatering of the tailings; and (5) changes in ground-water levels from reclamation actions. Pore pressures within and beneath the disposal cell/embankment are consistent with initial and as-built hydrologic site conditions. Methods used to determine settlement are appropriate for the tailings embankment and soil conditions at the site. The results of the settlement analyses are properly documented. The tailings embankment has been subdivided acceptably into assessment zones with appropriately assigned settlement magnitudes. The settlement data would provide information to assess the possibility of surface ponding or sudden change of gradient caused by settlement. An acceptable analysis for the development of cracks in the radon/infiltration barrier is provided.
>
> On the basis of information presented in the application and the detailed review conducted of the characteristics of the settlement at the _____________ mill facility, the NRC staff concludes that the settlement and associated conceptual and numerical models present information needed to demonstrate compliance with the following criteria in 10 CFR Part 40, Appendix A: Criterion 4(d), which requires establishment of a self-sustaining vegetative cover or employment of a rock cover to reduce wind and water erosion to negligible levels, that individual rock fragments are suited for the job, and that the impoundment surfaces are contoured to avoid concentrated surface runoff or abrupt changes in slope gradient, and Criterion 6(1), relating to providing reasonable assurance of control of radiological hazards to be effective for 1000 years to the extent reasonably achievable, and in any case for at least 200 years.

2.3.5 References

American Society for Testing and Materials (ASTM) Standards:

D 2435, “Test Method for One-Dimensional Consolidation Properties of Soil.”

D 4719, “Test Method for Pressuremeter Testing in Soils.”

Department of the Navy. 1982. *Soil Mechanics.* NAVFAC DM 7.1. May 1982.

Lee, K. L., and Shen, C.K., 1969, "Horizontal Movements Related to Subsidence," *ASCE Journal of Soil Mechanics and Foundations Division*, 95(SM1).

Nuclear Regulatory Commission. 1983a. "Consolidation of Tailings." NUREG/CR-3204. Washington, D.C.

Nuclear Regulatory Commission, 1983b. "Guidance for Disposal of Uranium Mill Tailings: Long-Term Stabilization of Earthen Cover Materials." NUREG/CR-3199. Washington, DC

Nuclear Regulatory Commission. 1983c. "Design Considerations for Long-Term Stabilization of Uranium Mill Tailings Impoundments." NUREG/CR-3397. Washington, D.C.

2.4 LIQUEFACTION POTENTIAL

2.4.1 Areas of Review

The staff shall review the analysis of the liquefaction potential of subsurface, pile, and embankment materials, and the associated test and data interpretations. Consequences of the liquefaction of subsurface soils and/or uranium mill tailings affecting the settlements within and stability of the disposal cell and the erosion protection layer shall also be reviewed. Design features or mitigation actions that address liquefaction potential shall be examined. The effect of settlements not induced by liquefaction is considered in SRP Section 2.3 and is also considered in SRP Section 2.4.3.

2.4.2 Review Procedures

The reviewer shall examine the analysis of liquefaction potential by studying the results of geotechnical investigations and *in situ* tests such as standard penetration, piezocone, density, and strength tests as well as boring logs, laboratory classification test data, water table, perched water zones, and soil profiles, to determine if any of the site soils or the tailings pile material could be susceptible to liquefaction.

If it is determined that there may be soils susceptible to liquefaction beneath the site or in the tailings pile, the reviewer shall examine the adequacy of site exploration methods, the laboratory test program, and the analyses. Where global liquefaction potential exists, the reviewer shall determine that it has been mitigated or eliminated. Minor or local liquefaction potential shall have been accounted for in settlement analyses.

The reviewer shall compare the liquefaction potential analysis in the RP to an independent study performed by the staff, if necessary.

2.4.3 Acceptance Criteria

The analysis of the liquefaction potential will be acceptable if the following criteria are met:

(1) Applicable laboratory and/or field tests are properly conducted (NRC, 1978, 1979; Army Corps of Engineers, 1970, 1972).

(2) Methods used for interpretation of test data and assessment of liquefaction potential are consistent with current practice in the geotechnical engineering profession (Seed and Idriss, 1971, 1982). An assessment of the potential adverse effects that complete or partial liquefaction could have on the stability of the embankment may be based on cyclic triaxial test data obtained from undisturbed soil samples taken from the critical zones in the site area (Seed and Harder, 1990; Shannon & Wilson, Inc., and Agbabian-Jacobsen Associates, 1972).

(3) If a potential for global liquefaction is identified, mitigation measures or redesign of tailings ponds/embankments are proposed and the proposed measure provides reasonable assurance that the liquefaction potential has been eliminated or mitigated.

(4) If minor liquefaction potential is identified and is evaluated to have only a localized effect that may not directly alter the stability of embankments, the effect of liquefaction is adequately accounted for in analyses of both differential and total settlement and is shown not to compromise the intended performance of the radon barrier. Additionally, the disposal cell is shown to be capable of withstanding the liquefaction potential associated with the expected maximum ground acceleration from earthquakes. The licensee may use post-earthquake stability methods based on residual strengths and deformation analysis to examine the effects of liquefaction potential. Furthermore, the effect of potential localized lateral displacement from liquefaction, if any, is adequately analyzed with respect to slope stability and disposal cell integrity.

2.4.4 Evaluation Findings

If the staff's review, as described in SRP Section 2.4, results in the acceptance of the licensee's liquefaction potential analysis and conclusions on the impact on the performance of the disposal cell, the following conclusions may be presented in the TER:

> The staff has completed its review of the liquefaction potential at the _____________ uranium mill facility. This review included an evaluation using the review procedures in SRP Section 2.4.2 and acceptance criteria outlined in SRP Section 2.4.3.
>
> The licensee has acceptably evaluated liquefaction potential based on results from properly conducted laboratory and/or field tests. The methods used for interpretation of test data are consistent with current practice. Where global liquefaction is identified, mitigation measures or redesign of tailings ponds/embankments are proposed and the new design provides reasonable assurance that the liquefaction potential has been eliminated or mitigated. In the case of minor/local liquefaction potential, its effect is accounted for in the analysis of both differential and total settlement and is shown not to compromise the intended performance of the radon barrier and erosion protection. Large settlement will change the profile of the erosion protection cover and may promote formation of gullies and other changes.

On the basis of the information presented in the application and the detailed review conducted of the liquefication potential at the _____________ uranium mill facility, the NRC staff concludes that the results of evaluation of liquefaction potential and associated conceptual and numerical models present input to a demonstration of compliance with the following criteria in 10 CFR Part 40, Appendix A: Criterion 4(c), which provides long-term stability requirements for the slopes of the tailings embankment and cover; Criterion 4(d), which requires establishment of a self-sustaining vegetative cover or employment of a rock cover to reduce wind and water erosion to negligible levels, that individual rock fragments are suited for the job, and that the impoundment surfaces are contoured to avoid concentrated surface runoff or abrupt changes in slope gradient; and Criterion 6(1), which requires a reasonable assurance of control of radiological hazards to be effective for 1000 years to the extent reasonably achievable, and in any case for at least 200 years.

2.4.5 References

American Society for Testing and Materials (ASTM) Standards:

D 3999, “Test Method for the Determination of the Modulus and Damping Properties of Soils Using the Cyclic Triaxial Apparatus.”

D 4015, “Test Method for Modulus and Damping of Soils by the Resonant-Column Method.”

Army Corps of Engineers. 1970. *Laboratory Soil Testing*, Engineering Manual EM1110-2-1906. November 1970.

Army Corps of Engineers 1972. *Soil Sampling*, Engineering Manual EM 1110-2-1907. March 1972.

Nuclear Regulatory Commission. 1978. "Laboratory Investigations of Soils for Engineering Analysis and Design of Nuclear Power Plants." Regulatory Guide 1.138. Washington, D.C. April 1978.

Nuclear Regulatory Commission, 1979. "Site Investigations for Foundations of Nuclear Power Plants." Regulatory Guide 1.132, Revision 1. Washington, D.C. March 1979.

Seed, H.B., and I.M. Idriss. 1971. "A Simplified Procedure for Evaluating Soil Liquefaction Potential," *Journal of Soil Mechanics and Foundation Division* 97(SM 9): 1249-1274.

Seed, H.B., and I.M. Idriss. 1982. "Ground Motions and Soil Liquefaction During Earthquakes." Earthquake Engineering Research Institute. *Engineering Monograph*: 5.

Seed, R.B., and L.F. Harder, 1990, "SPT-Based Analysis of Cyclic Pore Pressure Generation and Undrained Residual Strength." *Proceedings of the H. Bolton Seed Memorial Symposium.* Berkeley, California: University of California, May 10-11, pp. 351-376.

Shannon & Wilson, Inc., and Agbabian-Jacobsen Associates. 1972. "Soil Behavior Under Earthquake Loading Conditions: State-of-the-Art Evaluation of Characteristics for Seismic Responses Analyses." Washington, D.C. U.S. Atomic Energy Commission.

2.5 DESIGN OF DISPOSAL CELL COVER ENGINEERING DESIGN

2.5.1 Areas of Review

The staff shall review information presented related to disposal cell cover engineering design. including field exploration data, laboratory test results, design details, and construction and installation considerations pertinent to the geotechnical aspects of design and any associated geomembranes (i.e., disposal cell configuration and thickness, compaction requirements, gradations, permeability, and dispersivity).

2.5.2 Review Procedures

The reviewer shall examine the disposal cell design and engineering parameters to assess the geotechnical aspects of the disposal cell cover. Specific aspects of the review shall consider the following items:

(1) Determination that an adequate quantity of the specified borrow material has been identified at the borrow source;

(2) Confirmation that placement density, specific gravity, moisture content, dispersivity, and shrinkage properties used in the disposal cell design have been determined by suitable laboratory testing so that long-term stability standards will be met (Note that permeability issues are discussed separately in SRP Section 2.7.);

(3) Confirmation that appropriate measures for controlling the effects of erosion, surface water flows, and vegetative root penetrations have been taken;

(4) Verification that the particle size gradation of the disposal cell cover material, bedding layers, other layers in the cover, and the rock layer are compatible to ensure stability against particle migration during the period of regulatory interest;

(5) Determination that the disposal cell has been designed to accommodate the effects of anticipated freeze-thaw cycles;

(6) Assessment, if bentonite amendment to the radon barrier material of the disposal cell cover is proposed, of whether supporting discussions define appropriate laboratory testing and field procedures associated with evaluating amended materials;

(7) Determination if the cracking potential of the disposal cell has been adequately addressed [Cracking from both settlement and shrinkage shall be evaluated (this has been previously evaluated in SRP Section 2.3).];

(8) Assessment of the acceptability of plans for installation and use of any geomembranes; and

(9) Confirmation that the information used in the disposal cell cover design appropriately reflects the staff findings on the information reviewed using SRP Chapters 1.0, 2.0, 3.0, and 4.0.

Note that hydraulic conductivity aspects of the disposal cell cover design are assessed using SRP Section 2.7 and that review of the disposal cell design features is addressed in SRP Sections 2.2, 2.3, and 2.4. Review of the radon attenuation aspects of the disposal cell design is addressed in SRP Chapter 5.0.

2.5.3 Acceptance Criteria

The assessment of the disposal cell cover design and engineering parameters will be acceptable if it meets the following criteria:

(1) Detailed descriptions of the disposal cell material types [e.g., Unified Soil Classification System (Holtz and Kovacs, 1981)] and/or soil mixtures (e.g., bentonite additive) and the basis for their selection are presented.

An analysis is included demonstrating that an adequate quantity of the specified borrow material has been identified at the borrow source. The information on borrow material includes boring and test pit logs and compaction test data.

The soils that are considered suitable include the Unified Classification System classes CL, CH, SC, and CL-ML, with desirable characteristics and limitations as listed in Table 3-1 of the "Construction Methods and Guidance for Sealing Penetration in Soil Covers" (Bennett and Homz, 1991; Bennett and Kimbrell, 1991). The preferred material for the low-permeability layers is inorganic clay soil. This soil should be compacted to a low saturated hydraulic conductivity of at least 1×10^{-7} cm/sec.. For drainage layers, cobble types GW, GP, SP, and SW are recommended, with GW and GP being the preferred types (Bennett, 1991).

Measures for resisting cracking, heaving, and settlement, and providing protection from burrowing animals, root penetration, and erosion over a long period of time are described.

(2) A sufficiently detailed description of the applicable field and laboratory investigations and testing that were completed, and the material properties (e.g., permeability, moisture-density relationships, gradation, shrinkage and dispersive characteristics, resistance to freeze-thaw degradation, cracking potential, and chemical compatibility, including any amendment materials) are identified (Army Corps of Engineers, 1970, 1972; Fermulk and Haug, 1990; NRC, 1978, 1979; Lee and Shen, 1969; Spangler and Handy, 1982).

(3) Details are presented (including sketches) of the disposal cell cover termination at boundaries, with any considerations for safely accommodating subsurface water flows.

(4) A schematic diagram displaying various disposal cell layers and thicknesses is provided.

The particle size gradation of the disposal cell bedding layer and the rock layer must be established to ensure stability against particle migration during the period of regulatory interest (NRC, 1982).

(5) The effect of possible freeze-and-thaw cycle on soil strength and radon barrier effectiveness is adequately considered (e.g., Aitken and Berg, 1968).

If the region experiences prolonged freezing, the disposal cell cover may be affected by the freeze-thaw cycle. During freezing, ice crystals and lenses can form in the soil, causing heaving. On the other hand, during melting and thawing, the soil may lose its bearing capacity because of development of supersaturated conditions (Spangler and Handy, 1982). Major factors affecting growth of ice in soil are the temperature below the freezing point, the capillary characteristics of the soil, and the presence of water. The reviewer will check whether the soil is susceptible to frost heave, considering that uniformly graded soils containing more than 10 percent of particles smaller than 0.02 mm and well-graded soils with more than 3 percent of particles smaller than 0.02 mm are susceptible (Holtz and Kovacs, 1981; Spangler and Handy, 1982). After many freeze-thaw cycles, the soil may become a loose collection of aggregates with significantly reduced overall strength.

(6) A description is given (with sketches) of any penetrations (e.g., monitoring well) through the disposal cell system, including details of penetration sealing and disposal cell cover integrity. Bennett and Kimbrell (1991) suggest methods for seal design that are acceptable.

(7) An adequate analysis is presented of the potential for development of cracks in the disposal cell cover as a result of differential settlement and shrinkage. Note that cracking issues associated with settlement are discussed in SRP Section 2.3.3.

(8) An adequate description of the geomembranes and their major properties (e.g., physical, mechanical, and chemical) is provided if low permeability geomembranes are proposed as a part of the disposal cell cover. Methods for installation of the membranes in accordance with the manufacturer's recommendations are discussed. The shear strength of the interface between compacted clay and geomembranes used in the stability analyses under both static and dynamic loads is noted. The expected service life of the geomembrane is analyzed.

(9) Information on site characterization, slope stability, settlement, and liquefaction used in the disposal cell cover design appropriately reflects the staff's evaluation, and, therefore, constitutes inputs that would contribute to the demonstration of disposal cell design compliance with the regulations.

2.5.4 Evaluation Findings

If the staff's review as described in this SRP Section 2.5 results in the acceptance of the disposal cell cover design, the following conclusions may be presented in the TER:

> The staff has completed its review of the disposal cell cover design at the _____________ uranium mill facility. This review included an evaluation using the review procedures in SRP Section 2.5.2 and acceptance criteria outlined in Section 2.5.3. of the Title II SRP
>
> The licensee has acceptably presented the disposal cell cover design by presenting detailed descriptions of the disposal cell material types and/or soil mixtures, including the basis for their selection. The applicant has identified an adequate quantity of the specified borrow material at the borrow source. An acceptable schematic diagram displaying various disposal cell layers and thicknesses is provided. A description of the applicable field and laboratory investigations and testing is provided, including identification of material properties. The properties of the cover materials have been

measured properly using standards such as ASTM, NRC, or U.S. Army Corps of Engineers. Details (including sketches) have been provided of (1) disposal cell termination boundaries; (2) penetrations, including sealing and disposal cell integrity; and (3) geomembranes and their physical, mechanical, and chemical properties. Methods of installation for the membranes have been discussed and the expected service life has been justified. The analysis of the potential for development of cracks in the disposal cell cover is acceptable.

On the basis of the information presented in the application and the detailed review conducted of the disposal cell cover design at the _____________ uranium mill facility, the NRC staff has concluded that the disposal cell engineering parameters and associated conceptual and numerical models are acceptable and provide input to demonstration of compliance with the following criteria in 10 CFR, Part 40, Appendix A: Criterion 4(c), which provides requirements for the embankment and cover slopes for tailings; Criterion 4(d), which requires establishment of a self-sustaining vegetative cover or employment of a rock cover to reduce wind and water erosion to negligible levels, that individual rock fragments are suited for the job, and that the impoundment surfaces are contoured to avoid concentrated surface runoff or abrupt changes in slope gradient; and Criterion 6(1), which requires a reasonable assurance of control of radiological hazards to be effective for 1000 years to the extent reasonably achievable, and in any case for at least 200 years.

2.5.5 References

American Society for Testing and Materials (ASTM) Standards:

D 75, “Practice for Sampling Aggregates.”

D 4992, “Practice for the Evaluation of Rock To Be Used for Erosion Control.”

Aitken, G.W., and R.L. Berg, 1968. *Digital Solution of Modified Berggren Equation to Calculate Depths of Freeze or Thaw in Multi-layered Systems,* Special Report 122, Hanover, New Hampshire: Cold Regions Research & Engineering Laboratory, 1968.

Army Corps of Engineers. 1970. “Laboratory Soil Testing”, Engineering Manual EM1110-2-1906. November 1970.

Army Corps of Engineers. 1972. “Soil Sampling”, Engineering Manual EM1110-2-1907. March 1972.

Bennett, R.D. 1991. "Recommendations to the NRC for Soil Cover Systems Over Uranium Mill Tailings and Low-Level Radioactive Wastes: Identification and Ranking of Soils for Disposal Facility Covers." NUREG/CR-5432, Vol. 1. Washington, D.C.: Nuclear Regulatory Commission.

Bennett, R.D., and R.C. Homz. 1991. "Recommendations to the NRC for Soil Cover Systems Over Uranium Mill Tailings and Low-Level Radioactive Wastes: Laboratory and Field Tests for Soil Covers," NUREG/CR-5432, Vol. 2. Washington, D.C.: Nuclear Regulatory Commission.

Bennett, R.D., and A.F. Kimbrell. 1991. "Recommendations to the NRC for Soil Cover Systems Over Uranium Mill Tailings and Low-Level Radioactive Wastes: Construction Methods for Sealing Penetrations in Soil Covers," NUREG/CR-5432, Vol. 3. Washington, D.C.: Nuclear Regulatory Commission.

Fermulk, N., and M. Haug. 1990. "Evaluation of *In Situ* Permeability Testing Methods." *ASCE Journal of Geotechnical Engineering* 116(2): 297-311.

Holtz, R.D., and W.D. Kovacs. 1981. *An Introduction to Geotechnical Engineering,* Englewood Cliffs, New Jersey: Prentice-Hall.

Lee, K.L., and C.K. Shen. 1969. "Horizontal Movements Related to Subsidence," *Journal of Soil Mechanics and Foundation Division* 95(SM-1). New York: American Society of Civil Engineers.

Nuclear Regulatory Commission. 1978. "Laboratory Investigations of Soils for Engineering Analysis and Design of Nuclear Power Plants." Regulatory Guide 1.138. April 1978. Washington, D.C.

Nuclear Regulatory Commission. 1979. "Site Investigations for Foundations of Nuclear Power Plants." Regulatory Guide 1.132, Revision 1. March 1979. Washington, D.C.

Nuclear Regulatory Commission. 1982. "Rock Riprap Design Methods and Their Applicability to Long-Term Protection of Uranium Mill Tailings Impoundments," NUREG/CR-2684. Washington, D.C.

Spangler, M.G., and R.L. Handy, 1982. *Soil Engineering*. New York: Harper and Row.

2.6 CONSTRUCTION CONSIDERATIONS

2.6.1 Areas of Review

The staff shall review information on the geotechnical aspects of reclamation action construction. These aspects should include details such as the sequence of construction activities, material specifications and placement procedures, and quality control (QC) aspects of the construction procedures. The geotechnical aspects of the planned construction operations shall be reviewed to identify any deviations from standard engineering practice for earthworks, including measures to protect against erosion and provisions for a vegetative cover.

2.6.2 Review Procedures

The reviewer shall determine if all the tailings and contaminated materials at the site can be placed within the configuration of the proposed stabilized pile. The construction sequence shall be reviewed to verify the feasibility of achieving the intended final configuration of the tailings, particularly when tailings are to be relocated to new areas of the remediated pile and to determine whether the schedule for completion is reasonable.

The reviewer shall examine material placement, placement moisture content (drying, if needed), placement density, and desired permeability to ensure that design specifications shall be met. If mixing of the fine tailings (slimes) with sand tailings is proposed, the specifications to control the mixture and the determination of the engineering properties of this mixture shall be examined for adequacy.

The reviewer shall examine the proposed construction QC program to verify that adequate provisions have been included to ensure that the construction shall be in accordance with the NRC-approved RP. In particular, details of the proposed testing and inspection program, including the type and frequency of tests proposed, shall be reviewed and compared with NRC guidance on testing and inspection.

Methods and schedules for emplacing the vegetative cover shall be reviewed to determine that they are reasonable, and that seeds for the planned vegetation are compatible with the local climate.

2.6.3 Acceptance Criteria

The analysis of construction considerations will be acceptable if the following criteria are met:

(1) Engineering drawings are complete and clearly show the design features (e.g., embankments, ripraps, and channels).

(2) Sources and quantities of borrow material are identified, are shown to have been adequately characterized and quantified through field and laboratory tests, and are demonstrated to be adequate for meeting the geotechnical design requirements for disposal cell (NRC, 1978, 1979). The background levels of contamination in the borrow materials, if any, is properly established.

(3) Methods, procedures, and requirements for excavating, hauling, stockpiling, and placing of contaminated and noncontaminated materials, and other disposal cell materials are

provided and are shown to be consistent with commonly accepted engineering practice for earthen works (Department of the Navy, 1982a,b; Denson, et al., 1987).

Material placement and compaction procedures are adequate to achieve the desired moisture content (drying, if needed) and placement density and permeability. Recommendations made in NUREG/CR-5041 (Denson, et al., 1987) for gradation, placement, and compaction necessary to achieve design drainage rates and volumes, prevent internal erosion or piping, and allow for collection and removal of liquids are acceptable. Compaction specifications include restrictions on work related to adverse weather conditions (e.g., rainfall, freezing conditions).

Specifications for controlling the mixture of fine tailings (slime) with sand tailings are consistent with commonly accepted engineering practice and testing programs for determination of engineering properties of this mixture.

(4) A plan for embankment construction is presented, which demonstrates that embankments can be constructed in accordance with the design.

(5) Plans, specifications, and requirements for disposal cell compaction are supported by field and laboratory tests and analyses to assure stability and reliable performance.

(6) Testing and surveying programs to determine the extent of cleanup required are adequate. The contamination cleanup plan includes the method for determining the extent of the contaminated area and a confirmation program to demonstrate that the contaminated material has been removed. Details of the site cleanup (radiological aspects) are addressed in SRP Chapter 5.0.

(7) A plan for settlement measurement is provided that is satisfactory for producing representative settlement data throughout the area of the disposal cell. Settlement measurement stations are of sufficient coverage and are strategically placed to yield adequate information for determination of total, differential, and residual settlements. Monitoring monuments are designed to be durable. The reviewer shall also determine the reasonableness of the proposed monitoring frequency in accordance with NUREG/CR-3356 (NRC, 1983).

(8) It is shown that all tailings and contaminated materials at the site can be placed within the planned configuration of the stabilized pile.

(9) Procedures, specifications, and requirements for riprap, rock mulch, and filter production and placement are provided and are shown to be consistent with commonly accepted engineering practice and the design specifications (NRC, 1977, 1982).

(10) The construction sequence is described and demonstrated to be adequate to achieve the intended configuration for the tailings, particularly when tailings are to be relocated to new areas of the reclaimed pile. It is shown that the proposed time to completion is reasonably achievable.

(11) The vegetation program or rock cover design is described and demonstrated to be adequate (Wu, 1984; NRC, 1982).

(12) Appropriate QC provisions are provided to ensure that the construction will be in accordance with the RP. The descriptions of the methods, procedures, and frequencies by which the construction materials and activities are to be tested and inspected are reasonable and that appropriate records will be maintained (NRC, 1983).

(13) Tailings are placed below grade or the licensee has demonstrated that the above-grade disposal design provides reasonably equivalent isolation of the tailings from natural erosional forces. Tailings pile topographic features take into account wind protection and vegetation cover.

2.6.4 Evaluation Findings

If the staff's review as described in this section results in the acceptance of the licensee's proposed construction considerations, the following conclusions may be presented in the TER.

> The staff has completed its review of the construction consideration at the _____________ uranium mill facility. This review included an evaluation using the review procedures in Section 2.6.2 and the acceptance criteria outlined in Section 2.6.3 of the Title II SRP.
>
> The licensee has acceptably described the construction considerations by: (1) providing complete engineering drawings showing all design features; (2) describing sources and quantities of borrow material, including acceptable field and laboratory testing; and (3) identifying methods, procedures, and requirements for excavations, haulage, stockpiling, and placement of materials and demonstrating that all are consistent with accepted engineering practices for earthen works. An acceptable plan for embankment construction is provided. Disposal cell compaction plans are supported by field and laboratory tests that assure stability and performance. The licensee has an acceptable program to determine the extent of cleanup using appropriate testing and surveying programs. An acceptable plan for settlement measurement is provided, including (1) proper coverage and placement of settlement measurement stations; (2) durable monitoring monuments; and (3) reasonable monitoring frequencies. All tailings and contaminated materials have been demonstrated to fit within the planned configuration of the stabilized pile. Procedures, specifications, and requirements for riprap, rock mulch, and filters are provided and are shown to be consistent with commonly accepted engineering practices and design specifications. An acceptable construction sequence, including a reasonable time to completion, has been described. An acceptable vegetation program or rock cover design is proposed. Appropriate QC provisions are in place to ensure that construction will be in accordance with the reclamation plan and that appropriate records will be maintained.
>
> On the basis of the information presented in the application and the detailed review conducted of the construction considerations at the _____________ uranium mill facility, the NRC staff concludes that the construction considerations and associated conceptual and numerical models provide input to a demonstration of compliance with the following criteria in 10 CFR, Part 40, Appendix A: Criterion 4(c), which provides requirements for the embankment and cover slopes for tailings; Criterion 4(d), which requires establishment of a self-sustaining vegetative cover or employment of a rock cover to reduce wind and water erosion to negligible levels, that individual rock fragments are suited for the job, and that the impoundment surfaces are contoured to

avoid concentrated surface runoff or abrupt changes in slope gradient; and Criterion 6(1), relating to providing reasonable assurance of control of radiological hazards to be effective for 1,000 years to the extent reasonably achievable, and in any case for at least 200 years.

2.6.5 References

American Society for Testing and Materials (ASTM) Standards:

D 698, "Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort."

D 1556, "Test Method for Density and Unit Weight of Soil In Place by the Sand Cone Method."

D 1557, "Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort."

D 2167, "Test Method for Density and Unit Weight of Soil In Place by the Rubber Balloon Method."

D 2922, "Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)."

D 2937, "Test Method for Density of Soil in Place by the Drive Cylinder Method."

D 3017, "Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)."

D 3740, "Practice for the Evaluation of Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction."

D 4253, "Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table."

D 4254, "Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density."

D 4643, "Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method"

D 4718, "Practice for Correction of Unit Weight and Water Content for Soils Containing Oversize Particles."

D 4914, "Test Methods for Density of Soil and Rock In Place by the Sand Replacement Method in a Test Pit."

D 5030, "Test Method for Density of Soil and Rock in Place by the Water Replacement Method in a Test Pit."

Denson, R.H.,et al. 1987. "Recommendations to the NRC for Review Criteria for Alternative Methods of Low-Level Radioactive Waste Disposal," NUREG/CR-5041. Washington, D.C.: Nuclear Regulatory Commission.

Department of the Navy. 1982a. *Foundations and Earth Structures.* NAVFAC DM 7.2. May 1982.

Department of the Navy. 1982b. *Soil Dynamics, Deep Stabilization, and Special Geotechnical Construction,* NAVFAC DM 7.3. May 1982.

Nuclear Regulatory Commission. 1977. "Design, Construction, and Inspection of Embankment Retention Systems for Uranium Mills." Regulatory Guide 3.11, Revision 2, December 1977. Washington, D.C.

Nuclear Regulatory Commission. 1978. "Laboratory Investigations of Soils for Engineering Analysis and Design of Nuclear Power Plants," Regulatory Guide 1.138, April 1978. Washington, D.C.

Nuclear Regulatory Commission. 1979. "Site Investigations for Foundations of Nuclear Power Plants." Regulatory Guide 1.132, Revision 1. March 1979. Washington, D.C.

Nuclear Regulatory Commission. 1982. "Rock Riprap Design Methods and Their Applicability to Long-Term Protection of Uranium Mill Tailings Impoundments." NUREG/CR-2684. Washington, D.C.

Nuclear Regulatory Commission. 1983. "Geotechnical Quality Control: Low-Level Radioactive Waste and Uranium Mill Tailings Disposal Facilities," NUREG/CR-3356. Washington, D.C.

Wu, T.H. 1984. “Effect of Vegetation on Slope Stability: Soil Reinforcement and Moisture Effects on Slope Stability.” Transportation Research Record 965. Transportation Research Board, National Research Council.

2.7 DISPOSAL CELL HYDRAULIC CONDUCTIVITY

2.7.1 Areas of Review

The staff shall review test results, calculations, the technical bases for disposal cell design hydraulic conductivity values, the field testing program, and the QC program.

2.7.2 Review Procedures

The reviewer shall examine the geotechnical design aspects of the disposal cell to ensure that the disposal cell cover component has a minimal hydraulic conductivity, to limit radon emissions from, and water infiltration into, stabilized mill tailings. The geotechnical reviewer shall coordinate with the water resources protection reviewer (see SRP Chapter 4.0) to ensure that regulatory requirements for ground-water protection can be met by the proposed radon barrier.

The reviewer shall verify that an adequate technical basis has been presented for the design hydraulic conductivity (K) value for the disposal cell cover. For any situation in which a $K<10^{7}$ cm/sec is proposed by the licensee, the staff shall verify that either a test fill program will be undertaken to verify the constructability to achieve the desired K value, or the RP narrative and accompanying analyses have adequately demonstrated the acceptability of the design K value, considering some technical papers on this subject (e.g., Rogowski, 1990; Panno et al., 1991; Benson and Daniel, 1990). If the RP acceptably demonstrates that field testing is not required, the reviewer shall document the technical basis in the TER. If field testing is required, the staff shall ensure that the test fill specifications require that the hydraulic conductivity value be verified by in-place testing with double-ring infiltrometers or other approved methods.

The test reviewer shall examine the test fill construction plan and verification program for adequacy, including such aspects as (1) use of proper procedures and equipment for placement and compaction operations; (2) verification of the material and thickness for the barrier test zone; (3) comparison of gradation, bentonite amendment, and moisture/density testing with specifications; and (4) review of the QC plan.

2.7.3 Acceptance Criteria

The analysis of disposal cell hydraulic conductivity will be acceptable if it meets the following criteria:

(1) A sufficient technical basis is provided for the design hydraulic conductivity (K) value for the disposal cell.

The hydraulic conductivity is minimized by compacting fine-grained soil for a sufficient depth above the stabilized tailings. Natural borrow soils having insufficient silt and clay content to effectively reduce the hydraulic conductivity of the barrier can be amended with bentonite for improved effectiveness. (Note that construction issues are discussed separately in SRP Section 2.6).

(2) A field testing program adequate to verify the constructability of the disposal cell with a design hydraulic conductivity $K<10^{7}$ cm/sec is provided unless the RP demonstrates that field testing is not required (Benson and Daniel, 1990; NRC, 1979).

To meet to the U.S. Environmental Protection Agency (EPA) ground-water standards, designers of disposal cells for mill tailings sites are proposing increasingly smaller design hydraulic conductivity (K) values. It is not unusual for laboratory permeability test values to yield results of 10^{8} to 10^{10} cm/sec. Such tests are performed on compacted soil samples considered by the design engineer to represent the soil to be used for the disposal cell. However, several recent technical papers (Rogowski, 1990; Panno *et al.*, 1991; Benson and

Daniel, 1990) have raised serious questions concerning the exclusive use of laboratory testing for demonstrating hydraulic conductivity values in those cases in which a radon barrier K-value less than 10^7 cm/sec is specified. On the basis of these technical papers, field testing is necessary to confirm the radon barrier hydraulic conductivity, since construction operations and soil material variability can create preferred pathways, joints, seams, holes, and flaws that effectively increase the value of this parameter. Test results should take into consideration the variability and uncertainty in site conditions and material properties.

(3) An appropriate QC program is followed for the field testing to determine hydraulic conductivity (NRC, 1983).

For all cases in which $K<10^7$ cm/sec and the test fill program requirement has been defined, specifications and related documents (Remedial Action Inspection Plan, etc.) will require an adequate QC program. An acceptable QC program should contain mechanisms to ensure that as-built construction duplicates the test fill construction techniques on the cell barrier (NRC, 1983). The objective of the QC program will be to provide assurance that uniform and high-quality construction of the cell barrier has been achieved.

2.7.4 Evaluation Findings

If the staff's review as described in SRP Section 2.7 results in the acceptance of the disposal cell hydraulic conductivity, the following conclusions may be presented in the TER:

> The staff has completed its review of the disposal cell hydraulic conductivity at the _____________ uranium mill facility. This review included an evaluation using the review procedures in Section 2.7.2 and the acceptance criteria outlined in Section 2.7.3 of the Title II SRP.
>
> The licensee has acceptably evaluated the disposal cell cover materials' hydraulic conductivity by providing a sufficient technical basis for the design K-value for the disposal cell. A field testing program adequate to verify the constructability of the disposal cell with a hydraulic design conductivity of $K<10^7$ cm/sec is presented. The applicant followed an acceptable QC program for the field testing to determine the hydraulic conductivity.
>
> On the basis of the information presented in the application and the detailed review conducted of the disposal cell hydraulic condutivity at the _____________ uranium mill facility, the NRC staff concludes that the disposal cell hydraulic conductivity and associated conceptual and numerical models provide an acceptable input to the demonstration of compliance with the following criteria in 10 CFR, Part 40: Criterion 4(c), which provides requirements for the embankment and cover slopes for tailings: and Criterion 6(1), relating to providing reasonable assurance of control of radiological hazards to be effective for 1,000 years to the extent reasonably achievable, and in any case for at least 200 years.

2.7.5 References

American Society for Testing and Materials (ASTM) Standards:

D 2434. “Test Method for Permeability of Granular Soils (Constant Head).”

D 3385. “Test Method for Infiltration Rate of Soils in Field Using Double-Ring Infiltrometers.”

D 5093. “Test Method for Field Measurement of Infiltration Rate Using a Double-Ring Infiltrometer With a Sealed Inner Ring.”

Benson, C.H., and D.E. Daniel. 1990. "Influence of Clods on Hydraulic Conductivity of Compacted Clay," *ASCE Journal of Geotechnical Engineering* 116(8): 1231-1248, 1990.

Nuclear Regulatory Commission. 1979. "Site Investigations for Foundations of Nuclear Power Plants." Regulatory Guide 1.132, Revision 1. March 1979. Washington, D.C.

Nuclear Regulatory Commission, 1983. "Geotechnical Quality Control: Low-Level Radioactive Waste and Uranium Mill Tailings Disposal Facilities." NUREG/CR-3356. Washington, D.C.

Panno, S.V., et al. 1991. "Field-Scale Investigation of Infiltration Into a Compacted Soil Liner," *Ground Water* 29(6): 914-921.

Rogowski, A.S. 1990. "Relationship of Laboratory- and Field-Determined Hydraulic Conductivity in Compacted Clay Layer," EPA/600/S2-90/025, Cincinnati, Ohio: Risk Reduction Engineering Laboratory.

3.0 SURFACE WATER HYDROLOGY AND EROSION PROTECTION

The staff shall review hydrologic information, analyses, and design details presented in the reclamation plan (RP) and/or its supporting documents to ensure that the plan provides long-term erosion protection in accordance with the requirements in 10 CFR Part 40, Appendix A. Major areas of review are described in this Standard Review Plan (SRP), in Sections 3.1 through 3.5.

The surface water hydrology and erosion protection review plan is structured somewhat differently than the review plans for other technical areas, principally because the staff had previously developed detailed guidance for the design and review of erosion protection. This guidance initially appeared in the final staff technical position (FSTP), "Design of Erosion Protection Covers for Stabilization of Uranium Mill Tailings Sites." (The draft FSTP was developed in 1989 and completed in 1990, (NRC, 1990), after public comments were reviewed.) The staff recently developed modifications and improvements to the FSTP, and published a new report that updates the FSTP. This new report was published as NUREG-1623, "Design of Erosion Protection for Long-Term Stabilization" (NRC, 1998). Because very detailed guidance is available in these documents, the information contained in the FSTP or NUREG-1623 will not be repeated here. This SRP merely references the FSTP and NUREG-1623 as sources of design guidance for licensees and review guidance for the staff. The staff will use these documents in its review of reclamation plans to independently estimate flood potential and erosion protection requirements. Further, the technical bases provided in these documents will be used to determine the acceptability of various design approaches.

NUREG-1623 presents several new methods for evaluating erosion protection designs that were not included in the FSTP. These new methods include detailed techniques for assessing (1) channel outlets, (2) sedimentation in diversion channels, (3) construction specifications and quality assurance/quality control (QA/QC) programs, (4) aprons and toes, and (5) side slopes and top slopes.

NUREG-1623 also revises and improves several sections of the FSTP, on the basis of recent staff experience and new technical studies, and provides improved methods for assessing (1) gully intrusion, (2) design of sacrificial slopes, (3) rock durability, and (4) vegetative covers. In general, NUREG-1623 contains detailed guidance for the hydrologic and erosion protection aspects of the RP that will be reviewed by the staff.

It should be emphasized that NUREG-1623 suggests several (of many possible) acceptable methods for implementing the requirements of 10 CFR Part 40. However, as clearly stated in that document, use of these design methods is not required, and the licensee may propose alternate methods that are technically supported.

NUREG-1623 updates and replaces the FSTP, on the basis of experience gained in the Title I and Title II programs and additional research in the area of erosion protection design. Specific references related to design, analysis, and information needs for the RP are discussed in these documents. For general reference list, see SRP Section 3.6 (below).

3.1 HYDROLOGIC DESCRIPTION OF SITE

3.1.1 Areas of Review

Criterion 1 of Part 40, Appendix A, addresses the general goals of siting and designing facilities to provide for permanent isolation of tailings, and minimizing the potential for dispersion by natural forces, without the need for active maintenance. Information presented in SRP Section 3.1 will be used in later SRP sections to assess the ability of the site and the site design to meet this and other requirements of Part 40.

The staff will review hydrologic site characterization information, including (1) identification of the relationships of the site to surface-water features in the site area and (2) identification of mechanisms, such as floods and dam failures, that may require special design features to be implemented. This review requires identification of the hydrologic characteristics of streams, lakes (e.g., location, size, shape, drainage area), and existing or proposed water control structures that may adversely affect the long-term stability of the site design features.

It is important to note that the siting criteria presented in 10 CFR Part 40 are intended to apply to uranium mills that have not yet been constructed. For many, if not most, uranium mills, reclamation plans are developed for sites that have existed for several decades. In fact, many mills were producing uranium before the siting criteria were developed. Therefore, the staff concludes that Criterion 1 is more relevant to new facilities (or modifications to old facilities) than to facilities that existed before regulations were developed.

3.1.2 Review Procedures

The information normally presented is not amenable to independent verification, except through cross-checks with available publications related to hydrologic characteristics of the site region and through observation during site visits. The review procedure consists of evaluating the completeness of the information and data, by sequential comparison with information available from references. On the basis of the description of the hydrosphere (e.g., geographic location and regional hydrologic features), potential site flood mechanisms are identified.

The staff will also analyze geomorphic considerations, as described in SRP Chapter 1. On the basis of these analyses, the staff will estimate the potential for geomorphic instability to occur and to have a significant effect on the ability of the site and its protective features to prevent flood intrusion and erosion over a long period of time. If geomorphic problems are identified, the staff will give particular attention to several areas of the design, depending on site conditions and potential for geomorphic changes to occur. These areas include the (1) apron and toe of the disposal cell, (2) intersection of natural gullies with erosion protection features, and (3) diversion channel outlets. A detailed discussion of the erosion protection design for these and other features is given in SRP Section 3.4.2(below).

3.1.3 Acceptance Criteria

Acceptance of the information presented is based on a qualitative evaluation of the completeness and quality of information, data, and maps. The description of structures, facilities, and erosion protection designs should be sufficiently complete to allow independent evaluation of the impact of flooding and intense rainfall. Site topographic maps should be of good quality and of sufficient scale to allow independent analysis of pre- and post-construction drainage patterns.

The characterization of hydrologic information will be acceptable if the RP contains sufficient information for the staff to independently evaluate the hydraulic designs presented. In general, detailed information is needed for each method that is used to determine the hydraulic designs and erosion protection provided to meet NRC regulations. NUREG-1623 discusses acceptable methods for designing erosion protection to provide reasonable assurance of effective long-term control and thus conform to NRC requirements. NUREG-1623 also provides discussions and technical bases for use of specific criteria to meet the 1,000-year longevity requirement, without the use of active maintenance. Specific design methods are provided and form the primary basis for staff review of erosion protection designs. These criteria were derived from regulatory requirements, other regulatory guidance, staff experience, and various technical references.

3.1.4 Evaluation Findings

If the staff's evaluation of hydrologic and hydraulic engineering aspects of the RP confirms that the information presented in SRP Section 3.1 acceptably characterizes the site and the site design features, the following conclusions may be presented in the TER:

> The staff has completed its review of the flooding potential at the _____________ uranium mill facility. This review included an evaluation using the review procedures in Section 3.1.2 and acceptance criteria outlined in Section 3.1.3 of the Title II SRP.
>
> On the basis of the information presented in the application and the detailed review conducted of the flooding potential for the _____________ uranium mill facility the NRC staff concludes that (1) the flood analyses and investigations adequately characterize the flood potential at the site, (2) the analysesof hydraulic designs are appropriately documented, and (3) the general reclamation plan with respect to surface-water hydrology and erosion considerations represents a feasible plan for complying with the requirements of 10 CFR Part 40, Appendix A. The characterization of flood potential and the documentation of the site design comform to the requirements of Criterion 1 of 10 CFR Part 40, Appendix A, related to presenting a design that provides for permanent isolation of tailings and minimizes disturbance and dispersion by natural forces.

3.1.5 Reference

Nuclear Regulatory Commission. 1998. "Design of Erosion Protection for Long-Term Stabilization." NUREG-1623. Washington, D.C.

3.2 FLOODING DETERMINATIONS

3.2.1 Areas of Review

The staff will assess the flooding potential for the site, and will determine precipitation potential, precipitation losses, runoff response characteristics, and peak flow estimates for the probable maximum flood (PMF) or project design flood (if a flood less than the PMF is used). The staff will review the following design analyses: (1) the analyses and justification for the use of a flood less than the PMF, if applicable; (2) the probable maximum precipitation (PMP) potential and resulting runoff for site drainage and for drainage areas adjacent to the site; and (3) the modeling of physical rainfall and runoff processes to estimate flood conditions at the site.

The assessment of flooding also will include a review of possible geomorphic changes that could affect the erosion protection design for the site. As applicable, the staff will review the following: (1) identification of types of geomorphic instability; (2) changes to, and impacts associated with, flooding and flood velocities, from geomorphic changes; and (3) mitigative measures to reduce or control geomorphic instability. This information must be reviewed to determine the acceptability of hydraulic engineering designs to mitigate the geomorphic conditions.

The assessment of flooding will also include a review of potential dam failures, if upstream reservoirs exist. Peak water levels, flood routing procedures, and velocities will be reviewed in the determination of potential hazards because of failure of upstream water control structures from either seismic or hydrologic causes. If an existing analysis concludes that seismic or hydrologic events will not cause failures of upstream dams and produce the governing flood at the site, the analysis will be reviewed to verify that information that supports such a conclusion (e.g., record of contact with dam designers) is included. If an analysis is provided that concludes that a dam failure flood from a PMF or a seismically induced flood is the design-basis flood, the computations will be reviewed to verify that appropriate and/or conservative model input parameters have been used.

3.2.2 Review Procedures

The evaluation of flooding is, for review purposes, separated into two parts: (1) flooding on large adjacent streams, as applicable, and (2) localized flooding on drainage channels and protective features. The acceptability of using the PMF as the design flood event is presented in Section 2.2.1 of NUREG-1623 (NRC, 1998). The review procedure for evaluating a PMP/PMF event is outlined in Appendix D of NUREG-1623. For large drainage areas, PMF estimates approved by the Army Corps of Engineers and found in published or unpublished reports of that agency, or generalized estimates, may be used instead of independent staff-developed estimates. The staff will also assess flood history in the site area by examining historic regional flood data. For many areas, historic flood peaks could be a small percentage of the PMF. If the historic maximum floods exceed or closely approximate the proposed PMF estimates, the staff will perform a detailed evaluation to determine the basis for the estimates. The staff will compare basin lag times, rainfall distributions, soil types, and infiltration loss rates to determine if there is a logical basis for the PMF values being less than historic floods. Without such estimates, the staff will generally use Army Corps of Engineers' models to independently estimate PMF discharge and water levels at the site. If detailed computer models are used, the staff will review the adequacy of the various input parameters to the model, including, but not limited to, the following: drainage area, lag times and times of concentration, design rainfall, incremental rainfall amounts, temporal distribution of incremental rainfall, and runoff/infiltration relationships.

Information pertinent to computation of the design flood should be submitted in sufficient detail to enable the staff to perform an independent flood estimate. Acceptance of the analysis is based on acceptability of model input parameters, general agreement of the staff's and the RP estimates of flood levels and peak discharges; and the adequacy of the computational methods used for such estimates.

For dam failures, the staff will review the analyses presented in the RP or will independently estimate the peak flows at the site. The acceptable "worst conditions" that should be postulated in the analysis of upstream dam failures are (1) an approximate 25-year flood on a normal operating reservoir pool level coincident with the dam-site equivalent of the earthquake for which the remedial action project is designed; (2) a flood of about one-half the severity of a PMF on a normal reservoir pool level coincident with the dam-site equivalent of one-half of the earthquake for which the remedial action project is designed; and (3) a PMF (or design flood) on a normal reservoir pool. Conditions 1 and 2 are applied when the dam is not designed with adequate seismic resistance; condition 3 is applied when the dam is not designed to safely store or pass the design flood. Often, it may be much easier to perform simplified flood analyses assuming a dam failure, rather than detailed analyses of the seismic resistance of a dam. In such cases, the staff will review those simplified flood analyses using the procedures outlined in SRP Section 3.3.4 (below).

In those cases in which it is documented that it is clearly impractical to design erosion protection features for an occurrence of the PMF, the staff will evaluate the information presented in the RP using procedures found in Appendix C of NUREG-1623 (NRC, 1998). These documents contain detailed information regarding justification of a stability period of less than 1000 years. In general, a proposed design based on less than a PMF event must offer reasonable assurance of conforming to the stability requirement of 200 years. To assure that minimum NRC requirements are met, the staff will independently check and evaluate the ability of the design to resist such flood events

In the detailed review of flooding, the staff will carefully consider the following factors that are important in determining a local PMP/PMF event:

(1) Determination of Design Rainfall Event. The staff will consult appropriate hydrometeorological reports and determine that correct values of the 1-hour and 6-hour PMP events, as applicable, have been given.

(2) Infiltration Losses. The staff will check calculations to verify that appropriate values of infiltration have been selected.

(3) Times of Concentration. The staff will verify that appropriate methods (depending on the slope, configuration, etc.) have been selected. The staff will independently verify that the methods selected compare reasonably well with various velocity-based methods.

(4) Rainfall Distributions. The staff will verify that the rainfall distributions (particularly the 2½-minute, 5-minute, and 15-minute distributions) compare well with the distributions suggested in Appendix D to NUREG-1623 (NRC, 1998).

For dam failures, the acceptability and conservatism of the estimates of flood potential and water levels are reviewed. In general, depending on the potential for flooding, the staff will verify that the dam failure analyses are either realistic or conservative by determining locations and sizes of upstream dams, assuming an instantaneous failure (complete removal) of the dam embankment, and computing the peak outflow rate.

If this simplified analysis indicates a potential flooding problem, the analysis may be repeated using more refined techniques, and the staff may request additional information and data. Detailed failure models, such as those of the Army Corps of Engineers and National Weather Service, are used to identify the outflows, failure modes, and resultant water levels at the site.

If a flood less than a PMF can cause dam failure and is proposed as the design-basis flood, the staff will employ the review procedures outlined above to determine the impracticality of designing for a PMF and to determine the acceptability of the flood used.

3.2.3 Acceptance Criteria

In general, designs that conform to the suggested criteria in Appendix D to NUREG-1623 will be found acceptable. NUREG-1623 discusses acceptable methods for designing erosion protection to provide reasonable assurance of effective long-term control and to meet NRC requirements. It also presents discussions and technical bases for use of specific criteria to meet the 1,000-year longevity requirement without the use of active maintenance. Acceptable design methods are presented and form the primary basis for staff review of erosion protection designs. These methods were derived from regulatory requirements, other regulatory guidance, staff experience, and various technical studies.

3.2.4 Evaluation Findings

If the staff's evaluation of hydrologic and hydraulic engineering aspects of the RP confirms that the assessments of flooding are acceptable, the following conclusions may be presented in the TER.

> The staff has completed its review of the flooding potential at the _____________ uranium mill facility. This review included an evaluation using the review procedures in Section 3.2.2 and the acceptance criteria outlined in Section 3.2.3 of the Title II SRP.
>
> On the basis of information presented in the application and the detailed review conducted of the flooding potential for the ____________ uranium mill facility, the NRC staff concludes that the flood analyses and investigations adequately characterize the flood potential at the site and that the surface water hydrology and flooding considerations represent a feasible plan for meeting the requirements of 10 CFR Part 40, Appendix A.
>
> The mill tailings at the ____________uranium mill facility will be protected from flooding and erosion by an engineered rock riprap layer that has been designed in accordance with the guidance suggested by the staff. Flood analyses presented by the licensee demonstrate that this erosion protection is adequate, based on (1) selection of proper rainfall and flooding events; (2) selection of appropriate parameters for determining flood discharges; and (3) computation of flood discharges, using appropriate and/or conservative methods.
>
> The licensee presented analyses to show that the site is located in an area rarely flooded by offsite floods and that it is protected from direct onsite precipitation and flooding. The erosion protection is large enough to resist flooding from the shallow depths and minimal forces of floods occurring from a PMF in the upstream drainage area. The staff therefore concludes that the erosion potential at the proposed site has been acceptably minimized, since any flooding at the site is mitigated by the erosion protection, and the forces associated with offsite floods are minimal. The staff also concludes that because

the rainfall and flooding events have very low probabilities of occurrence over a 1,000-year period, no damage to erosion protection is expected from these, or more frequent, events. Therefore, maintenance or repair of damage will not be necessary.

On the basis of the information presented in the application and the detailed review conducted of the flooding potential for the _____________ uranium mill facility, the NRC staff concludes that the flood analyses contribute to meeting the following requirements of 10 CFR Part 40, Appendix A: Criterion 1, requiring that erosion, disturbance, and dispersion by natural forces over the long term are minimized and that the tailings are disposed of in a manner that does not require active maintenance to preserve conditions of the site; Criterion 4(a), requiring that upstream rainfall catchment areas are minimized to decrease erosion potential and to resist floods that could erode or wash out sections of the tailings disposal area; Criterion 6, requiring that the design be effective for a period of 200-1000 years; and Criterion 12, requiring that active maintenance is not necessary to preserve isolation.

3.2.5 Reference

Nuclear Regulatory Commission, 1998. "Design of Erosion Protection for Long-Term Stabilization." NUREG-1623. Washington, D.C.

3.3 WATER SURFACE PROFILES, CHANNEL VELOCITIES, AND SHEAR STRESSES

3.3.1 Areas of Review

The staff shall estimate the flood levels, velocities, shear stresses, and magnitudes, as described below. Staff estimates may be made independently from basic data, by detailed review and checking of the RP analyses, or by comparison with other estimates that have been previously reviewed in detail. The evaluation of the adequacy of the estimates is a matter of engineering judgment, and is based on the confidence in the estimate, the degree of conservatism in each parameter used in the estimate, and the relative sensitivity of each parameter as it affects the flood level, flood velocity, or design of the erosion protection.

Depending on the type of computational models used, the staff shall review the model, including the determination of flooding depths, channel velocities, and/or shear stresses used to determine riprap sizes needed for erosion protection. The staff shall review the various detailed computations for each model and will review the acceptability of the input parameters to the model.

3.3.2 Review Procedures

Using the guidance presented in Appendix D to NUREG-1623 (NRC, 1998) the staff shall verify that localized flood depths, velocities, and shear stresses used in models for rock size determination or soil cover slope analysis are acceptable. For offsite flooding effects, the staff will verify that computational models have been correctly and appropriately used and that the data from the model have been correctly interpreted. The staff will verify that acceptable models and input parameters have been used in all the various portions of the flood analyses and that the resulting flood forces have been adequately accommodated.

3.3.3 Acceptance Criteria

In general, designs that conform to the suggested criteria in Appendix D to NUREG-1623 will be found acceptable. NUREG-1623 discusses acceptable methods for designing erosion protection to provide reasonable assurance of effective long-term control and to comply with NRC requirements. This document also contains discussions and technical bases for use of specific criteria to meet the 1000-year longevity requirement without the use of active maintenance. Specific design methods are presented, and reasonable similarity to these methods forms the primary basis for staff acceptance of erosion protection designs. These criteria were derived from regulatory requirements, other regulatory guidance, staff experience, and various technical references.

3.3.4 Evaluation Findings

If the staff's evaluation of hydrologic and hydraulic engineering aspects of the RP confirms that the assessments of flooding are acceptable, the following conclusions may be presented in the TER:

> The staff has completed its review of the flooding models a the ____________ uranium mill facility. This review included an evaluation using the review procedures in Section3.3.2 and the acceptance criteria outlined in Section 3.3.3 of the Title II SRP. On the basis of the information presented in the application and the detailed review conducted of the flooding models for the ____________ uranium mill facility, the NRC staff concludes that flood velocities and forces associated with flooding at the site have been acceptably computed.
>
> The mill tailings will be protected from flooding and erosion by an engineered rock riprap layer that has been designed in accordance with the guidance suggested by the staff. Flood analyses presented by the licensee demonstrate that adequate protection is provided by (1) selection of proper models to assess rainfall and flooding events, (2) selection of appropriate parameters for models for determining flood forces, and (3) computation of flood forces using appropriate and/or conservative methods.
>
> The staff considers that the riprap layers proposed will not require active maintenance over the 1,000-year design life, because the licensee adopted models that conservatively compute flood forces used to design the erosion protection. Thus, the use of conservative design parameters will result in no damage to the erosion protection designed using those methods. The staff further concludes that the hydraulic design features are sufficient to protect the tailings from flood forces that are very large and have very low probabilities of occurrence over a 1000-year period. Therefore, maintenance of the rock layers will not be necessary.
>
> The staff concludes that the analyses and models used at the_____________ uranium mill facility contribute to meeting the following requirements of 10 CFR Part 40, Appendix A: Criterion 1, requiring that erosion, disturbance, and dispersion by natural forces over the long term are minimized and that the tailings are disposed of in a manner that does not require active maintenance to preserve conditions of the site; Criterion 6(1), requiring the design to be effective for a period of 200 1,000 years; and Criterion 12, requiring that active ongoing maintenance is not necessary o preserve isolation of the tailings.

3.3.5 Reference

NUREG-1620

Nuclear Regulatory Commission. 1998. "Design of Erosion Protection for Long-Term Stabilization." NUREG-1623. Washington, D.C.

3.4 DESIGN OF EROSION PROTECTION

3.4.1 Areas of Review

Design details and analyses pertinent to the following aspects of erosion protection will be reviewed, as applicable:

(1) Erosion protection for slopes and channel banks to protect against flooding from nearby large streams;

(2) Erosion protection for the top and side slopes of the pile;

(3) Erosion protection for the apron/toe area of the side slope;

(4) Erosion protection for drainage and diversion channels, including channel outlets;

(5) Durability of the erosion protection; and

(6) Construction considerations, including specifications, QA programs, quality control (QC) programs, and inspection programs.

In Section 3.4.2.4 (below), sedimentation in diversion channels is also addressed. It is interesting to note that Criterion 4(f) of 10 CFR Part 40, Appendix A, suggests that deposition of sediment in impoundment areas should be considered for enhancing the cover thickness. The staff considers it important to differentiate between beneficial and detrimental sediment accumulations. For example, if sediment could be conveniently routed to the middle of an impoundment, without long-term erosion or ponding of runoff that could affect ground-water conditions, such deposition may enhance long-term cover thickness. However, this is difficult to actually achieve. The major problem with sediment is that it tends to accumulate in diversion channels that are constructed on relatively flat slopes. High-velocity runoff from steep slopes carries sediment into low-velocity diversion channels, and that sediment can eventually accumulate and completely block the channel. Thus, it can be seen that some sediment buildup is good and some is bad.

3.4.2 Review Procedures

The staff will check the analyses in the RP or perform independent review analyses of floods, flood velocities, and rock durability according to the guidelines in Appendix D to NUREG-1623 (NRC, 1998). If the design assumptions and calculations are reasonable, accurate, and/or compare favorably with independent staff estimates, the designs are found acceptable.

(1) Banks of Natural Channels

The staff will review designs for riprap to be placed on the side slopes of a reclaimed pile or on natural channel banks to protect against erosive velocities from floods on large rivers. Guidance is presented in Appendix D to NUREG-1623 for assessing floods, determining input parameters to models, and determining riprap requirements.

(2) Top Slope and Side Slopes

The staff will review input parameters to calculations and models according to the recommendations given in Appendix D to NUREG-1623 and referenced technical procedures. The staff will assess the design flow rate, the depth of flow, angle of repose, specific gravity, and other parameters. For both the top and side slopes, the rock sizes will be checked using the recently developed, simplified procedures discussed in NUREG-1623.

(3) Apron/Toe

The design of the apron and toe is reviewed by verifying that several design features in this area have been properly designed, in accordance with the recommendations in NUREG-1623.

For the lower end of the side slope where it meets the toe, the staff will verify that proper consideration has been given to the potential occurrence of increased shear forces resulting from turbulence and energy dissipation produced by hydraulic jumps, when the flow transitions from supercritical to subcritical. The staff will verify that appropriate design criteria have been used to increase the rock size to account for the increased velocities or shear forces.

For the main area of the toe, the staff will assure that appropriate methods have been used to design the riprap, depending on the magnitude of the slope of the toe.

For the downstream end of the toe, the staff will verify that acceptable assumptions have been made regarding the assumed collapse of the rock into scoured areas to prevent gully intrusion. Flow concentrations, collapsed slopes, and computational models will be evaluated.

For the natural ground area at the downstream end of the toe, the staff will verify that appropriate methods have been used to compute scour depths and that natural erosion will not adversely affect long-term stability.

(4) Diversion Channels

Using the criteria and guidance presented in Appendix D to NUREG-1623, the staff will evaluate the design of diversion channels in several critical areas.

For the main channel area, the staff will verify that appropriate models and input parameters have been used to design the erosion protection. The staff will assure that flow rates, flow depths, and shear stresses have been correctly computed.

For the channel side slopes, the staff will verify that the side slopes are capable of resisting flow velocities and shear stresses from flows that occur directly down the side slope. This occurs often when diversion channels are constructed perpendicular to natural gullies (which discharge into the diversion channel). The shear forces in these locations often greatly exceed the forces produced by flows in the channel, particularly when the slope of the natural ground in the area is greater than the slope of the diversion channel.

For the outlet of the diversion channel, the staff will evaluate the design of erosion protection to assure that erosion in the discharge area (normally a natural gully, swale, or channel) has been adequately addressed. Designs similar to apron/toe designs will be evaluated to determine their resistance to erosion. Appendix D to NUREG-1623 discusses acceptable methods for designing channel outlets.

For the entire length of the diversion channel, the staff will evaluate the effects of sediment accumulations on flow velocities, channel capacity, and need for increased rock size. Particular attention will be given to designs in which steep natural streams discharge into relatively flat diversion channels, greatly increasing the potential for blockage of the channel. Appendix E to NUREG-1623 discusses acceptable methods for assessing sedimentation in diversion channels.

(5) Rock Durability

The staff will review the results of durability testing of proposed rock sources to assure that durable rock will be used. Appendix D to NUREG-1623 presents a detailed method for evaluating rock quality for various locations and applications.

(6) Construction Considerations

The staff will review the plans, specifications, inspection programs, and QA/QC programs to assure that adequate measures are being taken to construct the design features according to accepted engineering practices. The staff will compare the information presented with typical programs used in the construction industry. Appendix F to NUREG-1623 contains examples of acceptable specifications and testing programs that were approved by the staff and actually applied at several sites.

3.4.3 Acceptance Criteria

In general, designs that conform to the suggested criteria in NUREG-1623 will be found acceptable. NUREG-1623 discusses acceptable methods for designing erosion protection to provide reasonable assurance of effective long-term control and to meet NRC requirements. This document also provides discussions and technical bases for use of specific criteria to meet the 1000-year longevity requirement without the use of active maintenance. Acceptable design methods are presented, and reasonable similarity of the design to these methods forms the primary basis for staff review of erosion protection designs. These criteria were derived from regulatory requirements, other regulatory guidance, staff experience, and various technical references. NUREG-1623 updates and expands the FSTP (NRC, 1990).

If active maintenance is proposed as an alternative to the designs suggested above, such an approach will be found acceptable if the following criteria are met:

(1) The maintenance approach must achieve an equivalent level of stabilization and containment and protection of public health, safety, and the environment.

(2) The licensee must demonstrate a site-specific need for the use of active maintenanceand an economic benefit.

(3) The licensee must provide funding for the maintenance by increasing the amount of the required surety. The staff will determine if the licensee's estimate of funding required for active maintenance is adequate. The licensee should also work with the long-term custodian to assess any additional funding requirements related to long-term surveillance and monitoring.

3.4.4 Evaluation Findings

If the staff's evaluation of hydrologic and hydraulic engineering aspects of the RP confirms that the erosion protection designs are acceptable, the following conclusions may be presented in the TER:

> The staff has completed its review of the design of erosion protection at the _____________ uranium mill facility. This review included an e evaluation using the review procedures in Section 3.4.2 and the acceptance criteria outlined in Section 3.4.3 of the Title II SRP. On the basis of the information presented in the application and the detailed review conducted of the erosion protection designs are acceptable.
>
> The mill tailings will be protected from flooding and erosion by an engineered rock riprap layer. The riprap has been designed in accordance with the guidance suggested by the NRC staff. The staff considers that erosion protection that meets that guidance will provide adequate protection against erosion and dispersion by natural forces over the long term. In addition to the adequacy of the flood analyses discussed in SRP Sections 3.2 and 3.3, the staff concludes that adequate erosion protection designs are provided by (1) use of appropriate methods for determining erosion protection needed to resist the forces produced by the design discharge, and (2) selection of a rock type for the riprap layer that will be durable and capable of providing the necessary erosion protection for a long period of time. Further, the staff considers that the riprap layers proposed will be durable over the 1000-year design life, for the following reasons: (1) the rock proposed for the riprap layers was evaluated using rock quality procedures suggested by the staff and is not expected to deteriorate significantly over the 1000-year design life; (2) the rock fragments are dense, resistant to abrasion, and free from cracks, seams, and other defects; and (3) during construction, the rock layers will be placed in accordance with appropriate engineering and testing practices, minimizing the potential for damage, dispersion, and segregation of the rock.
>
> The riprap for the relatively flat top and side slopes is designed to be sufficiently large to minimize erosion potential. The rock will be capable of resisting flooding and erosion, depending on the slope selected. Thus, the staff concludes that the relatively steep slopes, with their corresponding rock designs, are acceptable.
>
> On the basis of its review of the designs for the _____________ uranium mill facility, the staff concludes that the hydraulic designs contribute to meeting the requirements of 10 CFR Part 40, Appendix A: (1) Criterion 1, requiring that erosion, disturbance, and dispersion by natural forces over the long term are minimized and that the tailings are disposed of in a manner that does not require active maintenance to preserve conditions of the site; (2) Criterion 4(c), requiring embankments and cover slopes to be relatively flat after stabilization to minimize erosion potential and to provide conservative factors of safety that ensure long-term stability; (3) Criterion 4(d), requiring that the rock cover reduces wind and water erosion to negligible levels, including consideration of such factors as the shape, size, composition, and gradation of the rock particles; (4) Criterion 6(1), requiring the design to be effective for 200-1,000 years; and (5) Criterion 12, requiring that active on-going maintenance is not necessary to preserve isolation.

3.4.5 References

Nuclear Regulatory Commission. 1998. "Design of Erosion Protection for Long-Term Stabilization." NUREG-1623. Washington, D.C.

Nuclear Regulatory Commission. 1990. “Design of Erosion Protection Covers for Stabilization of Uranium Mill Tailings Sites.” Washington, D.C.

3.5 DESIGN OF UNPROTECTED SOIL COVERS AND VEGETATIVE SOIL COVERS

3.5.1 Areas of Review

If an unprotected soil cover or a vegetative soil cover is proposed, the following design details, calculations, and analyses will be reviewed:

(1) Determination of allowable shear stresses and permissible velocities for the cover;

(2) Determination of allowable shear stresses and permissible velocities for the cover in a degraded state, including the effects of fires, droughts, vegetation succession, and other impacts to the ability of the cover to function without maintenance;

(3) Information on types of vegetation proposed and their abilities to survive natural phenomena; and

(4) Information, analyses, and calculations of all input parameters to models used.

3.5.2 Review Procedures

If a soil cover is proposed, the staff will evaluate the design using the general criteria outlined in Appendix A to NUREG-1623 (NRC, 1998). Particular attention will be given to the input parameters to various models.

(1) The staff will verify that the design flow rate includes an appropriate flow concentration factor that reflects consideration of settlement, soil removal by sheet flow and wind, degradation of the vegetation cover, intrusion of trees, blockage of flows by fallen trees, etc.

(2) The staff will verify that estimates of Manning's "n" value correspond to the vegetation cover proposed and are proper for estimating allowable shear stresses and permissible velocities.

(3) The staff will verify that appropriate values of allowable shear stresses and permissible velocities have been used and conservatively reflect potential changes that could occur to the cover over a long period of time as a result of fires, droughts, diseases, vegetation succession, or general cover degradation.

(4) The staff will check analyses and/or independently calculate allowable slopes using several different methods and ranges of input parameters. Using a range of flow concentration factors, shear stresses, permissible velocities, "n" values, and models, the staff will check the sensitivity of the analyses and will verify that reasonable and appropriate values of input parameters have been selected.

If a sacrificial soil cover is proposed to meet the minimum 200-year stability requirement, the staff will check the calculations using Appendix B to NUREG-1623 and the justification for reduction of the stability period using Appendix C to NUREG-1623.

3.5.3 Acceptance Criteria

In general, designs that conform to the suggested criteria in NUREG-1623 will be found acceptable. NUREG-1623 discusses acceptable methods for designing erosion protection to provide reasonable assurance of effective long-term control and thus meet NRC requirements. This document also provides discussions and technical bases for use of specific criteria to meet the 1000-year longevity requirement without the use of active maintenance. Specific acceptance criteria for many of the review areas are presented and form the primary basis for staff review of erosion protection designs. These criteria were derived from regulatory requirements, other regulatory guidance, staff experience, and various technical references.

If active maintenance is proposed as an alternative to the designs suggested above, such an approach will be found acceptable if the following criteria are met:

(1) The maintenance approach must achieve an equivalent level of stabilization and containment and protection of public health, safety, and the environment;

(2) The licensee must demonstrate a site-specific need for the use of active maintenance and an economic benefit; and

(3) The licensee must provide funding for the maintenance by increasing the amount of the required surety. The licensee should also work with the long-term custodian to assess any additional funding requirements related to long-term surveillance and monitoring.

3.5.4 Evaluation Findings

If the staff's evaluation of hydrologic and hydraulic engineering aspects of the reclamation plan confirms that the cover designs are acceptable, the following conclusions may be presented in the TER:

> The staff has completed its review of the design of erosion protection covers at the _____________ uranium mill facility. This review included an evaluation using the review procedures in Section 3.5.2 and the acceptance criteria outlined in Section 3.5.3 of the Title II SRP. On the basis of its review, the staff concludes that the designs are acceptable and meet the requirements of 10 CFR Part 40, Appendix A.
>
> The mill tailings will be protected from flooding and erosion by an engineered soil cover. The cover has been designed in accordance with the guidance suggested by the staff. The staff considers that a soil cover that meets that guidance will provide adequate protection against erosion and dispersion by natural forces over the long term. In addition to the adequacy of the flood analyses discussed in SRP Sections 3.2 and 3.3, the staff concludes that adequate cover designs are provided by
>
> (1) use of appropriate methods for determining cover slopes needed to resist the forces produced by the design discharge, and

(2) selection of a cover that will be capable of providing the necessary erosion protection for a long period of time.

The relatively flat top and side slopes of the cover are designed to provide long-term stability. The erosion potential of the cover is minimized by designing slopes that are sufficiently flat to minimize velocities and to resist flooding and erosion. Thus, the staff concludes that the cover slopes are acceptable.

On the basis of the information presented in the application and the detailed reviw conducted of the erosion protection covers for the _____________ uranium mill facility, the NRC staff concludes that the cover designs contribute to meeting the following requirements of 10 CFR Part 40, Appendix A:Criterion 1, requiring that erosion, disturbance, and dispersion by natural forces over the long term are minimized and that the tailings are disposed of in a manner that does not require active maintenance to preserve conditions of the site; Criterion 4(c), requiring that embankments and cover slopes are relatively flat after stabilization to minimize erosion potential and to provide conservative factors of safety; Criterion 6(1), requiring the design to be effective for 200 to 1,000 years; and Criterion 12, requiring that active ongoing maintenance is not necessary to preserve isolation.

3.5.5 Reference

Nuclear Regulatory Commission. 1998. "Design of Erosion Protection for Long-Term Stabilization." NUREG-1623. Washington, D.C.

3.6 GENERAL REFERENCES

American Nuclear Society. 1981. “American National Standard for Determining Design Basis Flooding at Power Reactor Sites.” ANSI/ANS-2.8.

Chow, V. T. 1959. *Open Channel Hydraulics*. New York: McGraw-Hill Book Co.

Crippen, J.R., and C.D. Bue. 1977. "Maximum Floodflows in the Conterminous United States." Water Supply Paper No. 1887. U.S. Geological Survey.

Fread, D.L. [n.d.] "DAMBRK: The NWS Dam-Break Flood Forecasting Model. National Weather Service: Silver Spring, Maryland. Continuously updated.

Henderson, F.M. 1971. Open Channel Flow. NewYork: MacMillan Co.: New York.

Interagency Advisory Committee (IAC) on Water Data, Hydrology Subcommittee Working Group on PMF Risk Assessment. 1985. "Draft Report on the Feasibility of Assigning a Probability to the Probable Maximum Flood." June 1985.

Nelson, J.D. Volpe, R.L., Wardell, R.E., Schumm, S.A., Staub, W.P. 1983. "Design Considerations for Long-Term Stabilization of Uranium Mill Tailings Impoundments.” NUREG/CR-3397, ORNL-5979. Washington, D.C. October 1983.

Nuclear Regulatory Commission. 1989. “Standard Format and Content for Documentation of Remedial Action Selection at Title I Uranium Mill Tailings Sites." February 1989.

Nuclear Regulatory Commission. 1990. "Design of Erosion Protection Covers for Stabilization of Uranium Mill Tailings Sites." Final Staff Technical Position.

Simons, D.B., and F. Senturk. 1977. “Sediment Transport Technology.” Water Resources Publications: Fort Collins, Colorado.

Stephenson, D. 1979. “Rockfill Hydraulic Engineering Developments in Geotechnical Engineering.” No.27, Elsevier Scientific Publishing Company.

Temple, D.M., et al. 1987. "Stability Design of Grass-Lined Open Channels." Agricultural Handbook Number 667. U.S. Department of Agriculture.

U. S. Army Corps of Engineers. [n.d.] "Flood Hydrograph Package." HEC-1. Davis, California: Hydrologic Engineering Center. Continuously updated.

Army Corps of Engineers. [n.d.] "Water Surface Profiles." HEC-2. Davis, California: Hydrologic Engineering Center. Continuously updated.

Army Corps of Engineers. [n.d.] "Reservoir System Operation for Flood Control." HEC-5. Davis, California: Hydrologic Engineering Center.

Army Corps of Engineers. [n.d.] "Hydraulic Design Criteria." Continuously updated and revised.

Army Corps of Engineers. 1948. "Stone Protection." CE 1308. January 1948.

Army Corps of Engineers. 1959. "Backwater Curves in River Channels." EM1110-2-1409. 7 December 1959.

Army Corps of Engineers. 1959. "Flood Hydrograph Analysis and Computations." EM1110-2-1405. 31 August 1959.

Army Corps of Engineers. 1960. "Routing of Floods through River Channels." EM1110-2-1408. March 1960.

Army Corps of Engineers. 1965. "Hydraulic Design of Spillways." EM1110-2-1603. 31 March 1965.

Army Corps of Engineers. 1965. "Standard Project Flood Determinations." EM1110-2-1411. March 1965.

Army Corps of Engineers. 1965. "Interior Drainage of Leveed Urban Areas: Hydrology." EM1110-2-1410. 3 May 1965.

Army Corps of Engineers. 1968. "Policies and Procedures Pertaining to Determination of Spillway Capacities and Freeboard Allowances for Dams." EC1110-2-27. February 1968.

Army Corps of Engineers. 1970. “Hydraulic Design of Flood Control Channels." EM1110-1601. 1 July 1970.

Army Corps of Engineers. 1971. "Additional Guidance for Riprap Channel Protection.” ETL1110-2-120. May 1971.

Army Corps of Engineers. 1980. "Runoff from Snowmelt." EM1110-2-1406. 5 January 1980.

Bureau of Reclamation. 1973. *Design of Small Dams.* Second Edition, U.S.Department of the Interior.

Bureau of Reclamation. 1986. "Comparison of Estimated Maximum Flood Peaks with Historic Floods."

Weather Bureau. [n.d.] Hydrometeorological Reports (now U.S. Weather Service, NOAA), Hydrometeorological Branch: Nos. 43, 49, 55

4.0 PROTECTING WATER RESOURCES

The protection of water resources is a process that encompasses two distinct strategies. The first strategy is to prevent the spread of contaminants from disposal and processing sites into ground water or surface water. This strategy requires the staff to ensure that operations and decommissioning are conducted in such a manner as to minimize threats to ground water.

The second strategy is to mitigate the threat to public health from contaminants that have already been mobilized—particularly through ground water pathways before decommissioning activities. This strategy applies only to those sites where ground-water contamination already exists and requires staff to review existing or proposed ground-water restoration activities to ensure that they will result in compliance with regulatory requirements.

Use of this chapter should be tailored to the specific situation and phase of operation at each site. The reviewer will select and emphasize the various aspects of the areas covered by this Standard Review Plan (SRP) chapter. The judgment on the areas to be given attention during the review is to be based on the specific licensee submittal being reviewed, an inspection of the material presented, prior knowledge of the site and its operating history, and whether items of special safety significance are involved.

This chapter presents a standard approach for reviewing, evaluating, and documenting the evaluation findings for issues pertaining to water resource protection during the various phases of the license termination process at licensed uranium mill sites. Review of information concerning the protection of water resources shall be coordinated with the evaluation of the site stratigraphy, structural and tectonic information, and surface water and erosion protection information as described in SRP chapters 1.0 and 3.0, respectively. Review procedures in this chapter pertain to the following four types of documents that are submitted for review by the staff during the license termination process:

(1) Licensees submit reclamation plans (RPs) to obtain approval of surface reclamation and decontamination work, including stabilization of mill tailings, and elimination (or isolation) of present or potential contaminant sources.

(2) Licensees submit corrective action plans during operations or during the license termination process to obtain approval of ground-water restoration strategies at sites where ground-water contamination has been detected

(3) Licensees submit ground-water completion reports to confirm that the ground-water quality will remain stable after ground-water restoration strategies have been implemented and that ground-water protection standards have been correctly established.

(4) Long-term custodians submit long-term surveillance plans to describe the monitoring activities that will be implemented by the custodian.

The ultimate objective of the review is to determine if the proposed RPs and corrective action plans will result in long-term compliance with 10 CFR Part 40, Appendix A. As stated in Part 40, Criterion 5, “Criteria 5A-5D and new Criterion 13 incorporate the basic ground-water protection standards imposed by the Environmental Protection Agency in 40 CFR, Part 192, Subparts D and E (48 FR 45926; October 7, 1983), which apply during operations and prior to the end of closure. Ground-water monitoring to comply with these standards is required by Criterion 7A.” To meet this regulatory objective, the following issues must be evaluated:

(1) Site characterization;

(2) Ground-water protection standards;

(3) Hazard and as low as is reasonably achievable (ALARA) assessment for alternate concentration limits (ACLs), as defined by Part 40, Appendix A, Criteria 5B(5) and 5B(6); and

(4) Ground-water corrective action and monitoring plans.

Accordingly, this chapter contains a section for each of these issues. Discussion about ACLs in this section of the SRP supersedes but does not replace, the existing technical position (TP) on ACLs (NRC, 1996). The licensee is encouraged to follow the format and content for an ACL application presented in the TP.

4.1 SITE CHARACTERIZATION

4.1.1 Areas of Review

The staff shall review the characterization information, given the circumstances and life cycle of a particular site, and the nature of the document under review (RP, corrective-action plan). The staff shall also evaluate regional and site-specific hydrologic information related to both the former processing site and the proposed disposal site if they are different. The hydrologic information shall include both surface-water and ground-water systems, along with any interrelations among those systems. Complete site characterization should include or reference the following:

(1) Site background data that include descriptions of

- (a) The site history of mining and/or milling operations;
- (b) Surrounding land and water uses; and
- (c) Site meteorological data.

(2) Ground water and surface-water hydrology data, including

- (a) Descriptions of hydrogeology and ground-water conditions;
- (b) Estimation of hydraulic and transport properties for each hydrogeologic unit;
- (c) Descriptions of surface-water hydrology and estimations of ground-water and surface-water interactions; and
- (d) Assessment of potential for flooding and erosion.

(3) Information concerning geochemical conditions and water quality, including

- (a) Identification of constituents of concern;
- (b) Determination of background ground-water quality;
- (c) Confirmation of proper statistical analysis;
- (d) Delineation of the nature and extent of contamination;
- (e) Identification of contaminant source terms;
- (f) Characterization of subsurface geochemical properties; and
- (g) Identification of attenuation mechanisms and estimation of attenuation rates.

(4) Human health and environmental risk evaluations.

4.1.2 Review Procedures

The level of effort necessary to adequately characterize a particular site depends on site-specific circumstances. For example, if a particular site has no ground-water contamination and tailings are disposed of off site, there will be very little need for detailed site characterization in support of water resources protection. Conversely, at a site with an existing source of ground-water contamination, the site characterization must be sufficient to support selection of restoration strategies and to determine the level of risk to human health and the environment.

Because the appropriate level of site characterization is specific to the methods of tailings disposal and ground-water corrective action selected for a particular site, there is not a single acceptable approach to conducting a site characterization. As such, the reviewer shall:

(1) Thoroughly evaluate the characterization information using the acceptance criteria in SRP Section 4.1.3, but reserve final judgment until all sections of the application have been reviewed; and

(2) Assess whether the level of detail and technical merit of the characterization are sufficient to support the proposals, assumptions, and assertions in the application that are used to demonstrate regulatory compliance.

4.1.3 Acceptance Criteria

Knowledge of the site is needed to evaluate the existing and potential contamination. This characterization information shall include a description of activities and physical properties that may affect water resources at the mill site. The site characterization will be acceptable if it meets the following criteria:

(1) It contains a description of the site that is sufficient to assess the environmental impact the former mill site may have on the surrounding area; the populations that may be affected by such impacts; and meteorological conditions that may act to transport contaminants off site. An acceptable site description will contain the following specific information:

  (a) A site history that includes

    (i) A list of the known leaching solutions and other chemicals used in the milling process and their relative quantities in mill wastes. The list should also identify any consistuent listed in 10 CFR Part 40, Appendix A, Criterion 13, that may have been disposed of in the tailings pile.

    (ii) A description of the wastes generated at the site during milling operations, waste discharge locations, types of retaining structures used (e.g., tailings piles, ponds, landfills), quantities of waste generated, and a chronology of waste management practices.

    (iii) A summary of the known impacts of the site activities on the hydrologic system and background water quality.

    (iv) If applicable, descriptions of any human activities or natural processes unrelated to the milling operation that may have altered the hydrogeologic system. Such human activities include ground water use, crop irrigation, mine dewatering, ore storage, municipal waste land filling, oil and gas development, or exploratory drilling. Natural processes include geothermal springs, natural concentration of soluble salts by evaporation, erosion processes, and ground-water/surface-water interactions.

(b) Information pertaining to surrounding land and water uses that includes

(i) A general overview of water uses, locations, quantities of water available, and the potential uses to which quality of water is suited;

(ii) Definitions of the class-of-use category for each water source (e.g., drinking water, agricultural, livestock, limited use);

(iii) Idetification of potential receptors of present or future ground-water or surface-water contamination; and

(iv) Descriptions of non-mill-related human activities or natural processes that may affect water quality or water uses (e.g., oil and gas development, municipal waste landfills, crop irrigation, drought, and erosion).

Human water consumption is not the only water use that must be considered in the review. Any use that may bring someone into contact with the contaminated water must be considered when evaluating health hazards. For example, non-potable, radon-contaminated water piped to a public lavatory could pose a substantial health hazard.

(c) Sufficient meteorologic data for the region, including rainfall, temperature, humidity and evaporation data in sufficient detail to assess projected water infiltration through the disposal cell.

Monthly averages are an acceptable means of presenting general meteorological conditions; however, the reviewer shall ensure that extreme weather conditions are adequately described.

(2) The ground-water and surface-water hydrology is described adequately to support modeling predictions of likely contaminant migration paths; selection of monitor well locations; and, when ground-water contamination exists, selection of a restoration strategy. The following specific information is provided to support these objectives:

(a) A description of hydrogeologic units that may affect transport of contaminants away from the site via ground-water pathways.

(i) Hydro-stratigraphic cross-sections and maps are included to delineate the geometry, lateral extent, thickness, and rock or sediment type of all potentially affected aquifers and confining zones beneath the processing and disposal sites and quantity to support a technically defensible interpretation.

(ii) The hydrogeologic units that constitute the uppermost aquifer (where regulatory compliance will be evaluated) are identified. The uppermost aquifer is the geologic formation nearest the natural ground surface that is an aquifer, as well as lower aquifers that are hydraulically interconnected with this aquifer within the facility’s property boundary.

(iii) If local perched aquifers are found at the site, their presence is noted. These formations may cause contaminated water to be diverted around monitoring systems, or may be improperly interpreted as the uppermost aquifer. Any saturated zone created by uranium or thorium recovery operations would not be considered an aquifer unless the zone is or potentially is (1) hydraulically interconnected to a natural aquifer, (2) capable of discharge to surface water, or (3) reasonably accessible because of migration beyond the vertical projection of the boundary, of the land transferred for long-term government ownership and care in accordance with Part 40, Appendix A, Criterion 11.

(iv) Unsaturated zones, through which contaminants may be conveyed to the water-bearing units, are described. This information is adequate to support the assumptions used in estimating the source term for contaminant transport pathways. This information includes identification of potential preferential flow pathways that are either natural (e.g., buried stream channels), or man-made (e.g., abandoned wells or mine shafts).

(v) Information is presented on geologic characteristics that may affect ground-water flow beneath the former mill site. Examples of pertinent geologic characteristics include identification of significant faulting in the area, fracture and joint orientation and spacing for the underlying bedrock, and geomorphology of soil and sedimentary deposits (e.g., fluvial, glacial, or volcanic deposits).

(vi) Hydraulic-head contour maps, of both local and regional scale, for the uppermost aquifer and any units connected hydraulically beneath the site are sufficient to determine hydraulic gradients, ground-water flow direction, and proximity to offsite ground-water users. These maps are based on static water level observations at onsite and regional wells. Several measurements are taken at each observation well [(ASTM) Standards D 4750, D 5092, D 5521, D 5787, and D 5978]. These measurements are sufficiently spaced in time to capture water-level fluctuations caused by seasonal changes or local pumping of ground-water. Enough observation wells are sampled to produce an adequate water elevation contour map. The appropriate number of wells is dependent on the size of the site and the choice of contour interval. However, as a rough estimate, there is at least one observation well for each contour line on the map. A more detailed contour map(small contour interval) is produced for the site and surrounding properties. The level of detail used for the regional contour map may be limited by the number of observation wells available off site. The reviewer shall bear in mind that calculations of hydraulic gradients from hydraulic head contour maps is only rigorously valid for horizontal flow in aquifers.

(b) Estimations of hydraulic and transport properties of the underlying aquifer.

Hydro-geologic parameters used to support the choice of a ground-water restoration strategy or to demonstrate compliance include hydraulic conductivity, saturated thickness of hydro-geologic units, hydraulic gradient, effective porosity, storage coefficient, and dispersivity. The reviewer shall consider the influence of each of these parameters on evaluating compliance with standards established pursuant to Part 40, Appendix A, and determine whether estimates for each parameter are reasonably conservative, based on the data provided.

(i) Hydraulic conductivity and storage coefficients are determined by conducting aquifer pump tests on several wells at the site. Pump test methods that are consistent with ASTM standards for the measurement of geotechnical properties and for aquifer hydraulic tests are considered acceptable by the NRC. These ASTM standards are D 4044, D 4050, D 4104, D 4105, D 4106, D 4630, D 5269, D 5270, D 5472, D 5473, D 5737, D 5785, D 5786, D 5850, D 5855, D 5881, and D 5912. Any other peer-reviewed method or commonly accepted practice for aquifer parameter estimation may be used. When curve fitting is used to analyze pump test data, deviations of observation data from ideal curves are explained in terms of likely causes (e.g., impermeable or recharge boundaries, leaky aquitards, or heterogeneities). When average hydraulic parameters are reported, the reviewer shall consider that many hydrogeologic parameters, including hydraulic conductivity, typically exhibit a log-normal distribution. Consequently, the geometric mean may be more representative of the overall conditions within a unit than the arithmetic mean.

(ii) Horizontal components of hydraulic gradient are estimated by measurement of the distance between contour intervals on hydraulic head contour maps. Vertical components of hydraulic gradient are estimated from head measurements in different aquifers or at different depths in the same aquifer.

(iii) Generally, analyses considering steady-state conditions are acceptable unless site conditions indicate otherwise. If transient conditions are modeled, storage coefficients estimated from standard tests indicated in (i) above are used.

(iv) If contaminant transport is modeled, then longitudinal and transverse dispersivity values are either obtained from a tracer test or conservative values based on published literature are used. Because dispersivities depend on the size of the modeled region, the reviewer shall carefully compare the values for dispersivity used in the licensee’s transport modeling with those values cited in survey studies such as Gelhar, Welty, and Rehfeldt (1992), and verify that they represent conservative estimates for the site.

(c) Estimation of ground-water/surface-water interactions at sites with nearby streams, rivers, or lakes.

The location of surface-water bodies that are connected to the site ground-water flow system are identified. Surface-water elevations shall be used to help describe the site ground-water flow system if a stream or other surface-water body discharges into or drains the site ground-water flow system. Another acceptable approach is to evaluate hydraulic head contour based on data from monitor wells in the vicinity of streams.

(3) Geochemical conditions and water quality are characterized sufficiently to

(a) Identify the constituents of concern.

Any chemical constituent that meets both of the following criteria must be listed as a constituent of concern:

(i) The constituent is reasonably expected to be in or derived from the tailings.

(ii) The constituent is listed in either Part 40, Appendix A, "Hazardous Constituent," Criterion 13, or it has been identified in a specific condition in the license.

Table 4.1.3-1 presents a list of constituents commonly associated with uranium mill tailings (Smith, 1987). This list is based on a chemical survey performed by NRC staff at 17 Title II sites.

Table 4.1.3-1. Common Uranium Mill Chemical Constituents

Inorganic Constituents	Organic Constituents
Arsenic	Carbon Disulfide
Barium	Chloroform
Beryllium	Diethyl Phthalate
Cadmium	2—Butanone
Chromium	1,2—Dichloroethane
Cyanide	Naphthalene
Lead	
Mercury	
Molybdenum	
Net Gross Alpha	
Nickel	
Radium-226 and -228	
Selenium	
Silver	
Thorium-230	
Uranium	

Most of the constituents in Part 40, Appendix A, Criterion 13 are organic compounds that are not normally associated with uranium milling processes. The expected presence of organic compounds is assessed from knowledge of the chemicals used during the milling process or other materials that may have been disposed of in the tailings. If there is no record of organic compounds used in the process, screening tests for volatile and semivolatile organics are performed to confirm the absence of organic compounds in the tailings and ground water.

Staff may require the addition of constituents associated with the milling process that are not specifically listed in Part 40, Appendix A, Criterion 13, to ground-water monitoring programs These constituents may be added on a case-by-case basis, if they are capable of posing a substantial present or potential hazard to human health or the environment. Before requiring the addition of such constituents, the reviewer should consider whether a constituent is covered by the State ground-water program and whether that program provides an adequate level of protection to human health and the environment. If the staff requires a constituent to be added to the list in Criterion 13, the NRC must establish an associated compliance limit for each added constituent at a level that will be protective of human health and the environment.

In identifying additional constituents, the staff should ensure that any additions are made based on a sound technical and regulatory basis. Examples of sound technical bases are the following:

- NRC and the Environmental Protection Agency (EPA) agree to use one Federal contact with a licensee, which is NRC. This approach requires NRC to include some constituents in its licenses, that are not normally licensed by the NRC.

- Trends in ground-water contamination show that after several years of decreases in the level of contamination, the level of contamination is beginning to rise again.

- Surrogate parameters that cover a family of constituents show an increase in the concentration in ground water. Therefore, the staff may require licensees to monitor for all constituents found in that family.

- Some constituents used in the milling process, but not listed in Criteria 13, need to be covered.

  Constituents should not be added just because an individual State regulatory body is concerned about that constituent. In identifying constituents of concern not covered in Criterion 13, the reviewer must ensure that an individual State does not use the NRC to implement the ground-water programs that are the responsibility of the State. Having a State identify a constituent as one of concern to the State is not necessarily a proper basis for NRC to include that constituent.

  Even if the criteria for identifying a constituent of concern are met, NRC may still decide to exclude certain constituents on a site-specific basis if it can be shown that the constituents are not capable of posing a substantial present or potential hazard to human health or the environment. In considering such exclusions, the reviewer must consider potential adverse effects on ground-water quality and hydraulically connected surface-water quality. NRC may decide to exclude a constituent if the dissolved concentration of the constituent in the tailing fluids is equal to or less than the concentration of that constituent in the background water quality. Alternately, NRC may decide to exclude a constituent if the dissolved concentration of the constituent in the tailing fluids is equal to or less than the maximum value for ground-water protection listed in Part 40, Appendix A, Table 5C.

  New constituents should be added in a timely manner. This is done either at the time the corrective-action plan is accepted for review, or at some time during the lifetime of the corrective-action plan. New constituents will not be required at the time of the license-termination monitoring submittal.

(b) Present a determination of background (baseline) water quality.

Background water quality is defined as the chemical quality of water that would be expected at a site if contamination had not occurred from the uranium milling operation.

Water quality data available from studies conducted in conjunction with initial licensing for operation of the facility are used to establish the background. If constituents of concern identified by NRC were not sampled in the original background monitoring program, the licensee should have conducted additional sampling to establish background levels. When adequate site-specific baseline data cannot be obtained for identified constituents of concern, samples of adjacent, and up-gradient, uncontaminated water are taken as proxies to onsite baseline samples.

To determine acceptability of the determination of background water quality, the following information is provided:

(i) Maps are of sufficient detail and legibility to show the background monitoring locations.

(ii) Descriptions of sampling methods, monitoring devices, and quality assurance (QA) practices are provided. Examples of acceptable methods are those that are consistent with ASTM Standards D 4448, D 4696, and D 4840. Other methods, if used, are properly referenced and justified.

(iii) When they exist, zones of differing background water quality are delineated. The possible causes of these differing water quality zones are discussed (e.g., changes from geochemically oxidizing to reducing zones in the aquifer; changes in rock type across a fault boundary).

(iv) A table for each zone of distinct water quality, listing summary statistics (i.e., mean, standard deviation, and number of samples) for baseline water quality sampling for each constituent of concern, is provided.

(v) A preoperational monitoring program has been in place for 1 year consistent with the requirements of Part 40, Appendix A, Criterion 7. Samples are taken at least monthly under this program. However, it is unlikely that mills in existence prior to the ground-water compliance provisions of 10 CFR 40 Appendix A will have one full year of monthly baseline data from a preoperational monitoring program.

Alternatively, background water quality may already be defined by a condition in the license. If this is the case, background limits for a ground-water protection standard have already been identified, and the reviewer should rely on those along with any constituents and standards listed in Criterion 5(c) as the regulatory limits applicable to this site.

(c) Confirm the proper use of statistical techniques for assessing water quality.

Statistical hypothesis testing methods used for (i) establishing background water quality; (ii) establishing ground-water protection standards for compliance monitoring; (iii) determining the extent of ground-water contamination; and (iv) establishing the ground-water cleanup goals, are described in Appendix B and ASTM Standard D 6312.

(d) Define the extent of contamination.

A hazardous constituent is defined in 10 CFR Part 40, Appendix A, Criterion 5B(2) as a constituent that meets all three of the following tests:

(1) The constituent is reasonably expected to be in or derived from the byproduct material in the disposal area;

(2) The constituent has been detected in the ground water in the uppermost aquifer; and

(3) The constituent is listed in Part 40, Appendix A, Criterion 13.

For each hazardous constituent, the licensee determines the extent of contamination in ground water at the site. Ground-water contamination at uranium mill sites is usually limited to the uppermost aquifer. Maps showing the locations of sampling wells should be included, along with a discussion of sampling practices. The most useful way to present this information is on a map showing concentration contours for each hazardous constituent and water surface elevation contours. In this manner, the reviewer readily examines the size, shape, source, and direction of movement. Sampling techniques suitable for characterizing the extent of ground-water contamination are discussed in SRP Section 4.1.3(3)(c).

The extent of contamination is delineated in three dimensions. This typically involves drilling a number of characterization wells and determining whether the water quality in each of these wells meets background water quality (i.e., null hypothesis) or whether the ground water is contaminated (i.e., alternative hypothesis). It may not be necessary to sample all hazardous constituents to delineate the extent of contamination. Two or three indicator parameters (e.g., total dissolved solids, and chloride) might be selected. These indicators should be conservative—meaning that they are neither reactive, nor are they easily sorbed to soil—so that they provide a good indication of the maximum extent of contamination.

The transition from contaminated to uncontaminated ground water is often gradual. Thus, difficulty arises in determining where the contaminated water ends and the background water begins. The background sample data provide the easiest means for comparison of characterization well measurements to background measurements for the indicator parameters. The easiest method is to use the tolerance limit method to determine the upper limit for the range of background concentrations; characterization wells with concentrations above this limit can be assumed to have been affected by ground-water contamination. Use of the tolerance limit method is discussed in SRP Section 4.2.3(3)(a).

Complications in delineating the extent of contamination arise at sites that have zones of differing water quality, or where onsite background water quality is not properly determined before discovery of ground-water contamination. Where zones of differing water quality are present, the reviewer shall verify that characterization wells are compared with the background sample from the appropriate water quality zone. Where onsite background water quality has not been properly determined, then upgradient or offsite samples are obtained, as discussed in SRP Section 4.1.3(3)(c).

The reviewer shall verify that the licensee has presented the following information to support determining the extent of contamination.

(i) A map or maps showing the distribution of surface wastes and contaminated materials at and near the site,

(ii) A map or maps showing the approximate shape and extent of ground-water contamination (e.g., concentration contour maps for indicator parameters in ground water), and

(iii) Identification of any offsite sources of water contamination or other factors that may have a bearing on observed water quality.

(e) Properly estimate the source term.

Existing sources of ground-water contamination are defined in terms of location and rate of entry into the subsurface. At some sites, the contaminant sources have been effectively eliminated through stabilization or removal of tailings piles. However, residual sources may still exist in contaminated subsurface soils at the site. For ground-water contamination that originates from an onsite tailings pile, the source term is determined based on the chemical properties of the leachate and the rate at which leachate is released from the disposal area. The level of review given to source term calculations is commensurate with the overall importance of source term estimations to the selection of the restoration strategy.

(i) Source terms are reasonably correlated to the history of ore processing. All facilities from which leakage can occur are identified. Leaking constituents are identified based on the nature of the processing fluids. The volume of leakage is estimated in a realistic yet conservative manner. This can be done using water balance calculations, infiltration modeling, or seepage monitoring approaches.

(ii) When geochemical models are used to predict the fate and transport of existing contamination where the original source has been eliminated, the distribution of each hazardous constituent in place is taken as the source term.

(f) Characterize the subsurface geochemical properties.

To effectively model the fate and transport of contaminants in ground water, it is important to characterize the geochemical properties of the natural waters and the aquifer mineralogy. Characterization of the underlying lithologies includes measurements of buffering capacity, total organic carbon, cation exchange capacity, and identification of the clay mineralogy. The general chemical characteristics of fluids within the lithologies are described by measurements of pH, temperature, dissolved oxygen, redox potential (Eh), buffering capacity, and the concentrations of major ions and trace metals.

(i) Aquifer geochemistry data are adequate to model the attenuation of contaminants. The values of the geochemical parameters used in transport models are justified. Acceptable parameter estimation methods are direct measurement, use of a conservative bounding estimate, reference to literature values for similar aquifer conditions, and laboratory studies of aquifer materials.

(g) Identify contaminant attenuation mechanisms.

The major attenuation mechanisms that work to mitigate the effects of ground-water contamination are dilution in surrounding ground water, sorption of contaminants to the soil matrix, and immobilization of contaminants from geochemical and biochemical reactions.

(i) Claims that contamination is reduced by dilution are supported by a sufficient technical basis. There are two mechanisms for dilution of a contaminant plume in ground water: dispersion and mixing. Dispersion is a process whereby contaminant plumes tend to spread out and become less concentrated as they are advected away from the source. Mixing is the result of uncontaminated water being added to the ground-water system through natural recharge, injection, or upward movement of water from underlying aquifers, which reduces the concentration of contaminants. Estimation of surface recharge or upward flow through leaky aquitards is either established from field measurements, or conservative assumptions are used.

(ii) The values of sorption coefficients are based on the nature of the constituent and site-specific geochemical conditions. The degree of sorption of contaminants to the soil matrix depends on the affinity of each constituent for the soil in a particular aquifer. Constituents that carry a positive charge, as do most trace metals in solution, are good candidates for cation exchange adsorption to clay and oxide surfaces. However, because surface charges of clays and oxides decrease with decreasing pH, the reviewer shall carefully examine claims of attenuation from cation exchange under low pH conditions. Organic contaminants tend to be hydrophobic and are strongly attenuated in soils that have high organic carbon content. Most contaminant fate and transport models quantify the affinity of contaminants for soil by use of a distribution coefficient or K_D. Batch or column equilibria experiments, using representative leachate and soil samples, are performed to support estimations of K_D for each hazardous constituent.

(iii) Attenuation from geochemical or biochemical equilibrium reactions are estimated by use of acceptable modeling software packages such as MINTEQA2 (Allison, Brown, and Novo-Gradac, 1991) and PHREEQE (Parkhurst, Thorstensen, and Plummer, 1980). However, these packages are limited in that they do not consider transport of contaminants. Thus, results are only valid for reactions within a confined space (e.g., within the disposal cell). The reviewer shall determine that all model input parameters have sufficient technical bases and represent reasonably conservative estimations. Additionally, conclusions drawn from such models are supported by field observation; that is, they are consistent with site characterization data.

(iv) At sites from which the contamination source has been effectively eliminated, monitoring data are used to assess attenuation of contaminants. If the contaminant source has been eliminated by surface reclamation, changes in the nature and extent of contamination over time are monitored. In such situations the center of mass of the contaminant plume moves along the direction of ground-water flow. The effects of dispersion are also observable over time as a decrease in peak concentrations near the center of the contaminant plume and a lateral spreading of the plume. If significant precipitation or adsorption is occurring, it is reflected in a decrease in the mass of contaminants in the aqueous phase.

4.1.4 Evaluation Findings

If the staff's review, as described in SRP Section 4.1, results in the acceptance of the site characterization, the following conclusions may be presented in the technical evaluation report TER:

> The staff has completed its review of the site characterization at the _____________ uranium mill facility. This review included an evaluation using the review procedures in Section 4.1.2 and the acceptance criteria outlined in Section 4.1.3 of the Title II SRP.
>
> The licensee has presented an acceptable history of the site, including (1) a description of leaching solutions and other chemicals used in the process and their relative quantities; (2) a description of (a) the wastes generated at the site during the milling process, and (b) the waste handling facilities; (3) a summary of the known impact of site activities on the hydrologic system and water quality; and (4) a description of activities unrelated to uranium milling that may have altered the hydrologic system.
>
> The licensee has presented acceptable information pertaining to the surrounding land and water use including (1) an overview of water uses, quantity available, and potential uses to which the water is suited; (2) definitions of the class-of-use category of each water source; (3) identification of potential receptors of ground-water or surface-water contamination; (4) assessment of variations in dilution effects of stream flow on contaminants; and (5) assessments of the effects of meteorological conditions on erosion, infiltration, and water-table elevation.
>
> The licensee has presented acceptable meteorologic data, including (1) wind speed and direction, (2) rainfall, (3) evaporation data (4) temperature, and (5) humidity, to allow an evaluation of potential impacts of the meteorologic conditions on disposal cell performance.
>
> The ground-water and surface-water hydrology is acceptably described, including (1) geometry, lateral extent, and thickness of potentially affected aquifers and confining units, (2) a determination of which aquifers constitute the uppermost aquifer where regulatory compliance will be evaluated; (3) descriptions of the unsaturated units that convey hazardous constituents to the water-bearing units; (4) maps of acceptable detail showing the relative dimensions and locations of hydrogeologic units that have been impacted by milling activities; (5) information on geologic characteristics that may affect ground-water flow beneath the site; and (6) hydraulic head contour maps of both local and regional scale for the uppermost aquifer beneath the site.
>
> The estimation of hydraulic and transport properties is acceptable and includes (1) hydraulic conductivity and storage coefficients determined by conducting aquifer pump tests on several wells, (2) determination of hydraulic gradients using hydraulic head contour maps, (3) calculations of storage coefficients, as applicable, and (4) longitudinal and transverse dispersivities, as appropriate. The evaluation of ground-water/surface-water interactions with nearby streams, rivers, or lakes is acceptable.

Geochemical conditions and water quality are acceptably analyzed, including identification of constituents of concern that are reasonably expected to be derived from the tailings. Each constituent of concern is found in Part 40, Appendix A, Table 5C or Part 40, Appendix A, "Hazardous Constituents," Criterion 13, or has been included as a specific condition in the license. The licensee has made an acceptable determination of baseline water quality, including (1) maps of appropriate scale and legibility; (2) descriptions of sampling methods, monitoring devices, and QA practices; (3) where applicable, delineation of zones of differing water quality and their possible origin; and (4) a table of summary statistics for each zone of differing quality. The applicant has presented an acceptable delineation of the extent of contamination supported by appropriate samples, maps of surface wastes and contaminated materials, maps of the approximate shape and extent of ground-water contamination, and identification of any offsite sources of water contamination. The description of the source term is acceptable and includes not only mill tailings constituents but those contaminants that might mobilize by contact with tailings leachate.

The characterization of the subsurface geochemical properties is acceptable. Attenuation mechanisms have been described, including the technical bases for determining that contamination will be reduced by dilution, sorption on the soil matrix, or geochemical or biochemical reactions. The licensee has presented direct measurements in support of attenuation of contaminants where the source has been eliminated by surface reclamation.

On the basis of the information presented in the application and the detailed review conducted of the site characterization for the _____________ uranium mill facility, the NRC staff concludes that the information is acceptable and is in compliance with the following criteria in Part 40, Appendix A: Criterion 5B, which requires the NRC to establish a list of hazardous constituents, concentration limits, a point of compliance (POC), and a compliance period; Criterion 5C, which provides a table of concentration limits for certain constituents when they are present in ground water above background concentrations; Criterion 5E, which requires licensees conducting ground-water protection programs to consider the use of bottom liners, recycle of solutions and conservation of water, dewatering of tailings, and neutralization to immobilize hazardous constituents; Criterion 5F, which requires that where ground-water impacts caused by seepage are occurring at an existing site, action be taken to alleviate the conditions that lead to seepage and that ground-water quality be restored, as well as providing technical specifications for the seepage control system and implementation requirements for a QA program; Criterion 5G, which requires that licensees/operators perform site characterization in support of a tailings disposal system proposal; Criterion 5H, which requires steps be taken during stockpiling of ore to minimize penetration of radionuclides into underlying soils; Criterion 7 which requires a year of monitoring prior to mill operations; Criterion 7A, which requires three types of monitoring systems: detection, compliance, and corrective action; and Criterion 13, which provides a list of hazardous constituents that must be considered when establishing the list of hazardous constituents in ground water at any site.

4.1.5 References

Allison, J.D., D.S. Brown, and K.J. Novo-Gradac. 1991. "MINTEQA2/PRODEFA2, A Geochemical Assessment Model for Environmental Systems: Version 3.0 User's Manual." Environmental Protection Agency Publication EPA/600/3-91/021.

American Society for Testing and Materials (ASTM) Standards

D 4044, “Standard Test Method for (Field Procedure) for Instantaneous Change in Head (Slug) Tests for Determining Hydraulic Properties of Aquifiers.”

D 4050, “Standard Test Method (Field Procedure) for Withdrawal and Injection Well Tests for Determining Hydraulic Properties of Aquifer Systems.”

D 4104, “Standard Test Method (Analytical Procedure) for Determining Transmissivity of Nonleaky Confined Aquifers by Overdamped Well Response to Instantaneous Change in Head (Slug Tests).”

D 4105, ‘Standard Test Method (Analytical Procedure) for Determining Transmissivity and Storage Coefficient of Nonleaky Confined Aquifers by the Modified Theis Nonequilibrium Method.”

D 4106, “Standard Test Method (Analytical Procedure) for Determining Transmissivity and Storage Coefficient of Nonleaky Confined Aquifers by the Theis Nonequilibrium Method.”

D 4448, “Standard Guide for Sampling Ground-water Monitoring Wells.”

D 4630, “Standard Test Method for Determining Transmissivity and Storage Coefficient of Low-Permeability Rocks by In Situ Measurements Using the Constant Head Injection Test.”

D 4750, “Standard Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well).”

D 4840, “Standard Guide for Sampling Chain-of-Custody Procedures.”

D 5092, “Standard Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers.”

D 5269, “Standard Test Method for Determining Transmissivity of Nonleaky ConfinedAquifers by the Theis Recovery Method.” D 5270-96, “Standard Test Method for Determining Transmissivity and Storage Coefficient of Bounded, Nonleaky, Confined Aquifers.”

D 5472, “Standard Test Method for Determining Specific Capacity and Estimating Transmissivity at the Control Well.”

D 5473, “Standard Test Method for (Analytical Procedure for) Analyzing the Effects of Partial Penetration of Control Well and Determining the Horizontal and Vertical Hydraulic Conductivity in a Nonleaky Confined Aquifer.”

D 5521, “Standard Guide for Development of Ground-Water Monitoring Wells in Granular Aquifers.”

D 5737, “Standard Guide for Methods for Measuring Well Discharge.”

D 5785, “Standard Test Method for (Analytical Procedure for) Determining Transmissivity of Confined Nonleaky Aquifers by Underdamped Well Response to Instantaneous Change in Head (Slug Test).”

D 5786, “Standard Practice for (Field Procedure) for Constant Drawdown Tests in Flowing Wells for Determining Hydraulic Properties of Aquifer System.”

D 5787, “Standard Practice for Monitoring Well Protection.”

D 5850, “Standard Test Method for (Analytical Procedure for) Determining Transmissivity, Storage Coefficient, and Anisotropy Ratio from a Network of Partially Penetrating Wells.”

D 5855, “Standard Test Method for (Analytical Procedure for) Determining Transmissivity and Storage Coefficient of a Confined Nonleaky or Leaky Aquifer by Constant Drawdown Method in a Flowing Well.”

D 5881, “Standard Test Method for (Analytical Procedure) Determining Transmissivity of Confined Nonleaky Aquifers by Critically Damped Well Response to Instantaneous Change in Head (Slug).”

D 5912, “Standard Test Method for (Analytical Procedure for) Determining Hydraulic Conductivity of an Unconfined Aquifer by Overdamped Well Response to Instantaneous Change in Head (Slug).”

D 5978, “Standard Guide for Maintenance and Rehabilitation of Ground-Water Monitoring Wells.”

D 6312, “Standard Guide for Developing Appropriate Statistical Approaches for Ground-Water Detection Monitoring Programs”

Gelhar, L.W., C. Welty, and K.R. Rehfeldt. 1992. “A critical review of data on field-scale dispersion in aquifers.” *Water Resources Research* 28(7).

Nuclear Regulatory Commission. 1996. “Staff Technical Position: Alternate Concentration Limits for Title II Uranium Mills.” Washington, D.C. January 1996.

Parkhurst, D.L., Thorstensen, and L.N. Plummer. 1980. “PHREEQEM-A Computer Program for Geochemical Calculations.” U.S. Geological Survey, Water Resources Investigation 80-96.

Smith, R.D. 1987. Memorandum: “Sampling of Uranium Mill Tailings Impoundments for Hazardous Constituents,” February 9, 1987.

4.2 GROUND-WATER PROTECTION STANDARDS

4.2.1 Areas of Review

Ground-water protection standards are established for each hazardous constituent. A hazardous constituent is defined in 10 CFR Part 40 Appendix A, Criterion 5B(2) as a constituent that meets all three of the following tests:

(1) The constituent is reasonably expected to be in or derived from the byproduct material in the disposal area;

(2) The constituent has been detected in the ground water in the uppermost aquifer; and

(3) The constituent is listed in Part 40, Appendix A, Criterion 13.

A constituent of concern that has been detected in the ground water in the uppermost aquifer is a hazardous constituent. Even when constituents meet the three aforementioned tests, the Commission may exclude a detected constituent from the set of hazardous constituents, on a site-specific basis, if it finds that the constituent is not capable of posing a substantial present or potential hazard to human health or the environment. In deciding whether to exclude constituents, the considerations identified in Part 40, Appendix A, Criterion 5B(3) must be considered. In addition, as required by Part 40, Appendix A, Criterion 5B(4), any underground sources of drinking water and aquifers exempted by EPA will be considered. Relevant EPA guidance is presented in 40 CFR 144.7, 144.3, and 146.4. The staff will review the technical basis the licensee has presented for the following elements of acceptable ground-water protection standards:

(1) The list of hazardous constituents;

(2) A description of the point of compliance (POC); and

(3) Ground-water protection standards for hazardous constituents may be either

- (a) Commission-approved background concentrations,
- (b) MCLs, or
- (c) ACLs.

Alternatively, the existing license may be referenced to determine acceptable ground-water protection standards.

The staff shall also review additional ground-water protection standards that contain provisions for ground-water protection dealing with the design of surface impoundments and tailings disposal cells. Evaluation of disposal system performance is addressed in SRP Section 4.3.3.

4.2.2 Review Procedures

The reviewer shall examine the ground-water protection standards to verify that they have been defined consistent with the acceptance criteria in SRP Section 4.3.2. Specifically, the reviewer shall reference the existing license or

(1) Verify that the licensee has identified all constituents of concern that are present in the tailings leachate.

(2) Verify that the POC has been properly delineated.

(3) Evaluate whether the proposed concentration limits for each ground-water protection standard are within a range that is reasonably expected to represent background concentrations; or, if any ACLs are proposed, verify that the appropriate evaluations have been presented in accordance with Criterion 5(B)(6) of Part 40, Appendix A.

4.2.3 Acceptance Criteria

Ground-water protection standards establish a concentration limit for each hazardous constituent, at the point of compliance. The development of ground-water protection standards will be acceptable if it meets the following criteria:

(1) Hazardous constituents are identified using the definition given in Part 40, Appendix A, Criterion 5(b).

(2) A POC is established in accordance with Part 40, Appendix A, Criterion 5B(1).

The POC is the location at which the ground water is monitored to determine compliance with the ground-water protection standards. The objective in selecting the POC is to provide the earliest practicable warning that the impoundment is releasing hazardous constituents to the ground water. The POC must be selected to provide prompt indication of ground-water contamination on the hydraulically downgradient edge of the disposal area. The POC is defined as the intersection of a vertical plane with the uppermost aquifer at the hydraulically downgradient limit of the waste management area.

The "uppermost aquifer" is defined in 10 CFR Part 40, Appendix A, as "the geologic formation nearest the natural ground surface that is an aquifer, as well as lower aquifers that are hydraulically interconnected with this aquifer within the facility's property boundary." Therefore, a proper selection of the POC includes identification of POC locations in the aquifer nearest to the ground surface, as well as other aquifers that are hydraulically interconnected with that aquifer, as warranted by site-specific conditions.

When tailings are disposed of on site, the NRC generally interprets the downgradient limit of the waste management area to be the edge of the reclaimed tailings side slopes. However, it is not recommended that licensees be required to compromise the cover integrity to install monitoring wells at the actual edge of the reclaimed tailings.

(3) A concentration limit is specified for each of the hazardous constituents.

(a) Commission-Approved Background Concentrations

Part 40, Appendix A, requires that the Commission-approved background concentration be the background concentration, except for constituents listed in Table 5C of Part 40, Appendix A, which, if present in excess of background, are subject to the respective MCL s listed in Table 5C.

Proper statistical methods, as discussed in SRP Appendix A, are used to determine the expected range of naturally occurring background (baseline) concentrations for each constituent of concern.

(b) Alternate Concentration Limits

ACLs are established on a site-specific basis, provided it can be demonstrated that (i) the constituents will not pose a substantial present or potential hazard to human health or the environment, as long as the ACLs are not exceeded and (ii) the ACLs are ALARA, considering practicable corrective actions. Licensees are required to implement detection-monitoring programs to detect and identify site-specific hazardous constituents, and compliance monitoring programs to verify compliance with the established site-specific standards for individual constituents. SRP Sections 4.3.3 and 4.4.3 contain acceptance criteria for determining potential hazards, and for ALARA demonstrations, respectively.

4.2.4 Evaluation Findings

If the staff's review, as described in SRP Section 4.2, results in the acceptance of the site ground-water protection standards, the following conclusions may be presented in the TER:

> The staff has completed its review of the ground-water protection standards at the _____________ uranium mill facility. This review included an evaluation using the review procedures in Section 4.2.4 and the acceptance criteria outlined in Section 4.2.3 of the Title II SRP.
>
> The licensee has acceptably identified the hazardous constituents and has established acceptable concentration limits and cleanup standards. Established background levels are acceptable. Acceptable statistical methods, such as those in Haan (1977) and Hirsch et al. (1992), have been used to establish the concentration limits. If ACLs have been requested, the licensee has acceptably supported the request with appropriate data and calculations. The licensee has established an acceptable POC at the edge of the tailings impoundment on the downgradient direction of hydraulic flow.
>
> On the basis of the information presented in the application and the detailed review conducted of the ground-water protection standards for the ____________ uranium milling facility, the NRC staff concludes that the information is acceptable and is in compliance with the following criteria in Part 40, Appendix A: Criterion 5B, which requires the NRC to establish a list of hazardous constituents, concentration limits, a POC, and a compliance period; Criterion 5(B)(5), which allows use of ACLs under certain conditions; Criterion 5C, which provides a table of secondary concentration limits for certain constituents when they are present in ground water above background concentrations; Criterion 7A, which requires three types of monitoring systems: detection, compliance, and corrective action; and Criterion 13, which provides a list of hazardous constituents that must be considered when establishing the list of hazardous constituents in ground water at any site.

4.2.5 References

Haan, C.T., 1977,. *Statistical Methods in Hydrology*, Iowa State University Press 1977.

Hirsch, R.M., D.R. Helsel, T.A. Cohn, and E.J. Gilroy, 1992, *Statistical Analysis of Hydrologic Data*, *Handbook of Hydrology*, D.R. Maidment, ed., New York: McGraw-Hill, Inc.

4.3 HAZARD AND ALARA ASSESSMENT FOR ALTERNATE CONCENTRATION LIMITS

4.3.1 Areas of Review

ACLs must be protective of human health and the environment at the POE. ACLs which "are not protective of human health and the environment" will not satisfy the ACL framework. Instances such as these would have to be submitted to the Commission as special cases outside the ACL framework, and will be addressed and decided on by the Commission on a case-by-case basis.

The staff shall review the following elements of ACL hazard assessments:

(1) Identification of a POE;

(2) Characterization of the hazardous constituent source term and the extent of ground-water contamination;

(3) Assessment of hazardous constituent transport in the ground water and hydraulically connected surface waters, and their adverse effects on water quality, including present and potential health and environmental hazards;

(4) Assessment of human and environmental exposure to hazardous constituents, including the cancer risk and other health and environmental hazards; and

(5) A demonstration that hazardous constituent concentrations will not pose substantial present or potential hazards to human health or the environment at the POE, and that the ACLs are ALARA, considering practicable corrective actions.

4.3.2 Review Procedures

The reviewer shall examine the information and assessments provided for establishing ACLs to make the following determinations:

(1) The hazardous constituent source term has (a) been characterized; (b) is sufficient to provide a defensible estimate of the types, characteristics, and release rates of hazardous constituents that have been or are anticipated to be released from the source term; and (c) the extent of ground-water contamination at the site has been defined.

(2) The rates and directions of hazardous constituent migration and transport in the ground water and hydraulically connected surface waters have been adequately determined.

(3) The pathways for human and environmental exposure to hazardous constituents have been identified, and exposure magnitudes and effects, including the cancer risk, have been acceptably evaluated.

(4) The ACLs proposed at the POC are at a level that will allow the constituent concentrations to be protective of human health and the environment at the POE, considering the attenuation capacity of the aquifer between the POC and the POE. There will be no adverse effects on the ground water or on surface-water quality that would cause substantial health or environmental hazards at or beyond the POE location(s).

The licensee's assessment of ground-water corrective action alternatives shall be reviewed in conjunction with the hazard assessment. Previous, current, and proposed practicable corrective actions shall be reviewed to determine if the licensee has demonstrated that the proposed ACLs are ALARA. The demonstration should include identification of alternative corrective actions; assessment of their technical feasibility, implementation, costs, and benefits; and selection of preferred corrective actions.

4.3.3 Acceptance Criteria

The hazard and ALARA assessments for ACLs will be acceptable if they meet the following criteria:

(1) A hazard assessment is performed, that in accordance with Part 40, Appendix A, Criterion 5B(6), and as required by Part 40, Appendix A, Criterion 5B(4), considers any underground sources of drinking water and exempted aquifers identified by EPA.

The hazard assessment reviewer shall consider all factors listed in Part 40, Appendix A, Criteria 5B(6)(a) and (b), as they apply to the site conditions. The assessment addresses the present and potential health and environmental hazards, including the cancer risk caused by human exposure to radioactive constituents and other health hazards that may be caused by the chemical toxicity of constituents.

The acceptability of the proposed ACL values is based on a finding that the constituent will not pose a substantial present or potential hazard to human health and the environment as long as the ACL is not exceeded. The use of previously established and documented health-based constituent concentration limits in the hazard assessment is used as a basis for establishing ACL values at specific sites, or such values are determined for constituents for which health-based concentration limits have not been established.

(2) The POE is identified.

The POE is defined as the location(s) at which people, wildlife, or other species could reasonably be exposed to hazardous constituents from the ground water. For example, the POE may be represented by one or more domestic wells that might withdraw contaminated ground water, or it may be represented by rivers, streams, or lakes into which contaminated ground water might discharge. In most cases, the POE is located at the downgradient edge of land that will be transferred to either the Federal Government or the State for long-term institutional control. The concept of a POE is used to assess the potential hazard to human health and the environment. ACLs for hazardous constituents are extablished at the POC. The POE may be situated at some distance from the POC, allowing the hazardous constituent concentrations to diminish through dispersion, attenuation, or sorption within the aquifer. As a result, an ACL may be set at a concentration that is higher than a limit that would be protective of hymban health and environment at the POC location, as long as the hazardous constituent concentration at the POE protects human health and the environment.

A distant-POE could be justified, on the basis that land ownership by the licensee or the long-term care custodian would ensure that groundwater from the contaminated aquifers between the disposal site and the POE would not be used. In some rare instances, a distant-POE may be established without invoking land ownership or long-term custody. Land ownership or long-term custody will not be an issue for establhishing a distant POE, if the possibility of human exposuer is effectively impossible. When ground water is inaccessible or unsuitable for use, human exposure is considered effectively impossible.

When a distant POE is involved, the licensee is required to coordinate and work with NRC to determine whether the State or the Federal Government will be the long-term site custodian after the termination of the NRC license, and to provide necessary documentation that can be used to secure a commitment from that party to take custody of the site. ACLs may not be established at sites involving a distant POE unless and until the licensee agrees to transfer the title to the land, and the appropriate Federal or State government commits to take such land, including the land between the POC and POE that is in excess of the land used for disposal of byproduct material. In instances in which the licensee chooses to keep the mill property under a specific license and apply for an ACL as part of a compliance monitoring program, the licensee would still be required to coordinate and work with NRC to secure a commitment from the State or from the Federal Government Agency that will accept the transfer of the specific property after the termination of the specific license, including land in excess of that used for disposal of byproduct material.

Written assurance must be secured, either by the licensee or NRC, that the appropriate Federal or State agency will accept the transfer of the specific property, including land in excess of that needed for tailings disposal. ACLs are not established at sites with a distant POE unless and until the licensee agrees to transfer the title to the land, and the appropriate Federal or State government commits to take such land.

(3) The hazardous constituent source term and the extent of ground-water contamination are characterized.

Characterization of the contaminant source(s) and their extent provides the source term for contaminant transport assessments. The source characterization provides reliable estimates of the release rates of hazardous constituents as well as constituent distributions.

The source term characterization provides relevant information about the facility, including (a) the uranium recovery processes used, (b) types and quantities of the reagents used in milling, (c) milled-ore compositions, and (d) historical and current waste management practices. This information is considered, in conjunction with the physical and chemical composition of the waste and the type and distribution of existing contaminants, to characterize the source term and evaluate future hazardous constituent release into the ground water (e.g., location of waste discharges, retaining structures for wastes, and waste constituents).

Depending on the hazardous constituents present, the following additional information on them and their properties is provided: (a) density, solubility, valence state, vapor pressure, viscosity, and octanol-water partitioning coefficient; (b) presence and effect of complexing ligands and chelating agents, to the extent that constituent mobility may be enhanced; (c) potential for constituents to degrade because of biological, chemical, and physical processes; and (d) constituent attenuation properties, considering such processes as ion exchange, adsorption, absorption, precipitation, dissolution, and ultrafiltration.

At sites with well-defined contaminant plumes, the spatial distribution of the various hazardous constituents is specified. This information calibrates contaminant transport models and supports evaluations of whether humans and environmental populations are being exposed to elevated concentrations of hazardous constituents. Characterization of the contamination extent includes (a) the type and distribution of hazardous constituents in the ground water and contamination sources; (b) the monitoring program used to delineate and characterize hazardous constituent distribution; and (c) documentation of the sampling, analysis, and quality assurance (QA) programs followed in the implementation of the site monitoring programs. Such information is used to assess present human and environmental population exposure to elevated concentrations of hazardous constituents, calibrate contaminant transport models, and evaluate projected future exposures.

(4) The hazardous constituent transport in ground water and hydraulically connected surface water and the adverse effects on water quality, including the present and potential health and environmental hazards, are assessed.

The hydrogeologic and contaminant transport assessment provides and documents estimates of projected contaminant distribution, including contaminant transport and degradation and attenuation mechanisms between the POC and the POE. The assessment generally characterizes and provides information on (a) site hydrogeologic characteristics, including ground-water flow direction and rates; (b) background water quality; and (c) estimated transport rates, geochemical attenuation, and concentrations of hazardous constituents in the ground water and hydraulically connected surface water. The acceptance criteria for these data are contained in SRP Section 4.3.2.

All likely and significant pathways of hazardous transport in ground water and surface water should be identified and assessed. Estimated hazardous constituent concentrations and projected distributions are either best estimates or reasonably conservative representations of the rate, extent, and direction of constituent transport.

In the past, the staff has found it acceptable to project impacts at the POE over a 1,000-year time frame. This is consistent with the design standard of 10 CFR 40, Appendix A, Criterion 6(1) which states that licensees “shall close the waste disposal area in accordance with a design which provides reasonable assurance of control radiological hazards to (i) be effective for 1,000 years, to the extent reasonably achievable, and at any case, for at least 200 years.”

Projections should be calibrated on the basis of site-specific information. When there is great uncertainty in the attenuation-rate estimate, the licensee may rely on measurements of constituent concentrations at the POC and the POE over a sufficient time period, before ACLs are established, to verify the projected attenuation rate.

(5) An assessment of human or environmental exposures to hazardous constituents, including cancer risk and other health and environmental hazards, is provided.

The exposure assessment identifies the maximum levels permissible at the POC that are protective of human health and the environment at the POE by evaluating human and environmental exposure to hazardous constituents and then demonstrating that the proposed ACLs do not pose substantial present or potential hazards to human health or the environment.

The exposure assessment at specific sites evaluates health and environmental hazards using water classification and water use standards, and existing and anticipated water uses. Agricultural, industrial, domestic, municipal, environmental, and recreational water uses, as they pertain to the site, are considered. The assessment identifies and evaluates hazardous constituent exposure pathways and makes projections of human and environmental population response based on the projected constituent concentrations, dose levels, and available information on the radiological and chemical toxicity effects of hazardous constituents. The assessment addresses the underlying assumptions and variability of the projected health and environmental effects.

The human exposure assessment is evaluated primarily on the basis of the extent to which people are using, and are likely to use, contaminated water from the site. Site-specific water uses are determined on the basis of the following considerations: (a) ground-water quality in the site area and present water uses; (b) statutory or legal constraints and institutional controls on water use in the site area; (c) Federal, State, or other ground-water classification criteria and guidelines; (d) applicable wateruse criteria, standards, and guidelines; and (e) availability and characteristics of alternate water supplies.

The human exposure assessment considers two potential exposure pathways: (a) ingestion of contaminated water and (b) ingestion of contaminated foods. The assessments distinguish between health effects associated with threshold and nonthreshold constituents. Mutagenic, teratogenic, and synergistic effects are considered in the analysis, if applicable, based on toxicological testing, structure-activity relationships, or epidemiological studies. Other pathways that may impact human health, such as dermal contact and inhalation, are also to be considered, but need not always be assessed, unless it is determined that these exposures could result in significant hazards to human health or the environment.

The assessment of adverse effects associated with present and potential human exposure to hazardous constituents should be based on the exposure pathways characterization. The human exposure assessment includes (a) classification of affected water resources, (b) assessment of existing and potential water uses, (c) evaluation of the likelihood that people will be exposed to hazardous constituents, and (d) evaluation of adverse effects associated with exposure to hazardous constituents, including assessment of the permanence and persistence of adverse effects.

Assessments of the probability of human exposure are often difficult to establish quantitatively. Consequently, defensible qualitative estimates are often necessary, and can be characterized as either

(a) Reasonably likely -- when exposure has or could have occurred in the past, or available information indicates that exposure to contamination may reasonably occur during the contamination period, or

(b) Reasonably unlikely -- when exposure could have occurred in the past, but will probably not occur in the future, either because initial incentives for water use have been removed, or because available information indicates that no incentives for water use are currently identifiable, based on foreseeable technological developments.

Information in support of the exposure assessment should be supplied, or relevant information and studies, such as those available from the International Commission on Radiological Protection and the National Council on Radiation Protection and Measurement, for the effects of radioactivity, and EPA's Integrated Risk Information System, for chemical-toxicity effects, should be referenced. Alternatively, site-specific information presented in previous reports, such as the license application or the environmental report, can be referenced. A technical basis to establish a reasonable assurance that the proposed ACLs do not pose a hazard to human health or the environment should be provided for each constituent for which an ACL may be established.

Exposure determinations should consider existing and potential water uses. Potential uses include those uses that are reasonably sure to occur (i.e., anticipated use) and uses that are compatible with the untreated background water quality (i.e., possible use). Past uses may be included as existing or potential uses.

Water resource classification of existing and potential water use should include (a) domestic and municipal drinking-water use, (b) fish and wildlife propagation, (c) special ecological communities, and (d) industrial, agricultural, and recreational uses. The classification of existing and potential uses of water at the facility should be consistent with Federal, State, and local wateruse inventories. Water yields, costs for development of alternate water supply sources, and legal, statutory, or other administrative constraints on the use and development of the water resources should be verified.

The cancer risk should be evaluated for individual constituents, including radioactive and carcinogenic chemicals, and compared with the maximum permitted risk level. The health effects of non-radioactive and non-carcinogenic constituents that are chemically toxic will be evaluated considering their risk-specific dose (RSD) levels, and for some chemicals that have threshold effects, it will be necessary to calculate a hazard index using the reference doses (RfDs). The hazard index is the ratio of calculated intake to the RfD, and an acceptable hazard index must be less than unity.

Reasonably conservative or best estimates of potential health effects caused by human exposure to hazardous constituents should include an assessment of potential health hazards for each constituent for which an ACL is proposed, based on comparisons of existing and projected constituent concentrations with appropriate exposure limits and dose-response relationships from the available literature. This assessment of potential health hazards should include the MCLs, RfDs, or RSDs. MCLs represent the EPA standards for drinking water; they are found in Part 40, Appendix A, Table 5C. RfDs are the amounts of toxic constituents to which humans can be daily exposed without suffering any adverse effect. RSDs are the amounts of proven or suspected carcinogenic constituents to which humans can be daily exposed, without increasing their risk of contracting cancer, above a specified risk level.

MCLs, RfDs, and RSDs for most hazardous constituents in uranium mill tailings can be obtained from EPA. The RfD and RSD assessment assume a human mass of 70 kg (154 pounds) and consumption of 2 liters of water per day (0.53 gallon/day). More-stringent criteria may apply if sensitive populations are exposed to hazardous constituents. MCLs, RfDs, and/or RSDs, can be used to show compliance with the risk level and hazard indices. In the absence of applicable MCLs, RfDs, or RSDs, a technical basis for the risk assessment can base dose-response relationships on literature searches or toxicological research. The exposure analysis should distinguish between threshold (toxic) and non-threshold (carcinogenic) effects associated with human exposure, as well as teratogenic, fetotoxic, mutagenic, and synergistic effects.

The cumulative effects of human exposure to hazardous constituents for which ACLs are proposed and to other constituents present in contaminated ground water will be maintained at a level adequate to protect public health. The combined effects from both radiological and non-radiological constituents should be considered.

Proposed human exposure levels should be reasonably conservative, defensible, and sufficiently protective of human health to avoid a substantial present or potential hazard to people for the estimated duration of the contamination. When considering the potential for health risks from human exposure to known or suspected carcinogens in the use of ground water for drinking purposes, an ACL that does not exceed an excess lifetime risk of fatal cancer on the order of 10^{-4} for an average exposed individual at the POE would be acceptable.

Potential responses of environmental or nonhuman populations to the various hazardous constituents are assessed if such populations can realistically be exposed to contaminated ground water or hydraulically connected surface water. Terrestrial and aquatic wildlife, plants, livestock, and crops are included in the assessment. In the absence of available information that readily may be used to demonstrate that there will be no substantial environmental impacts caused by ground-water contamination from the site, the exposure assessment provides (a) inventories of potentially exposed environmental populations, (b) recommended tolerance or exposure limits, (c) contaminant interactions and their cumulative effects on exposed populations, (d) projected responses of environmental populations that result from exposure to hazardous constituents, and (e) anticipated changes in populations, independent of the hazardous constituent's exposure. Alternatively, a licensee demonstrates that environmental hazards are not anticipated, because exposure will not occur.

The potential for adverse effects, such as (a) contamination-induced biotic changes, (b) loss or reduction of unique or critical habitats, and (c) jeopardizing endangered species, should be described. Aquatic wildlife effects are evaluated by comparing estimated constituent concentrations with Federal and State water-quality criteria. Consultation with the U.S. Fish and Wildlife Service is required under the Endangered Species Act, if an endangered or threatened species is found on the site, or is believed to inhabit the site. Terrestrial wildlife exposure to constituents through direct exposure and food-web interactions should be considered.

Agricultural effects from both direct and indirect exposure pathways, crop impacts, reduced productivity, and bioaccumulation of constituents should be considered. Reasonably conservative estimates of constituent concentrations are compared with Federal and State water-quality criteria to estimate agricultural effects associated with constituent exposure. Additionally, crop exposures through contaminated soil, shallow ground-water uptake, and irrigation, along with livestock exposure through direct ingestion of contaminated water and indirect exposure through grazing, should be assessed.

When appropriate, the hazard assessment considers potential damage to physical structures (e.g., from corrosiveness), that may result from exposure to the hazardous constituents in ground water and hydraulically connected surface water. Alternatively, a licensee demonstrates that damage to physical structures is not anticipated, because the exposure will not occur.

For physical structures, such as foundations, underground pipes, and roads, the reviewer ensures that estimated constituent concentrations will not result in any significant degradation or loss of function as a result of contamination exposure.

(6) An ALARA demonstration is provided.

Applications for ACLs must demonstrate that the proposed limits are ALARA, considering practicable corrective actions, as required by Criterion 5B(6) of Appendix A. The ALARA analysis for non-radiological constituents should be similar to the ALARA analysis for radiological constituents except a “dollar per person rem avoided” value would not be calculated. The applicant must provide a site-specific assessment of ground-water corrective action alternatives that are available for the site. The corrective action assessment incorporates the information and findings from the site characterization activities, which are described in SRP section 4.1.3. Site-specific characteristics may have a strong influence on which corrective action alternatives will be practicable for a particular site. For some sites, a corrective action assessment may have already been completed as part of a ground-water corrective action program under Criterion 5D of Appendix A, as described in SRP section 4.4.3. A ground-water corrective action assessment typically: (a) identifies several practicable corrective action alternatives; (b) assesses the technical feasibility, costs, and benefits of each alternative; and (c) selects an appropriate corrective action for achieving compliance with the ground-water protection standards established at the site.

Once an ACL has been proposed, based on the findings of the hazard assessment, the applicant must then show that the limit is ALARA, considering the corrective actions identified in the corrective action assessment. The ALARA assessment should be performed on target concentration levels that are at or below the limit determined to be protective of human health and the environment. At least three target concentration levels that can be reasonably be attained by the practicable corrective actions should be evaluated. The goals should be (1) meaningfully different, (2) reasonably attainable by practicable corrective action, and (3) at or below the level identified in the hazard assessment. The ALARA assessment typically considers: (a) the direct and indirect benefits of implementing each corrective action to achieve the target concentration levels; (b) the costs of performing the corrective action to achieve the target concentrations; and (c) a determination whether any of the evaluated corrective action alternatives will reduce contaminant levels below the proposed ACL, considering the benefits and costs of implementing the alternative.

The direct benefits of implementing the corrective actions can be determined by estimating the current and projected resource value of the pre-contaminated ground water. Estimates of pre-contaminated ground water value should be based on water rights, availability of alternative water supplies, and forecasted water use demands. The value of a contaminated water resource is generally equal to the cost of a domestic or municipal drinking water supply or the cost of water supplied from an alternative source to replace the contaminated resource. The absence of available alternative water supplies increases the relative value of a potentially contaminated water resource. The indirect benefits are determined by assessing the avoidance of adverse health effects from exposure to contaminated water, the prevention of land value depreciation, and any benefits accrued from performing the corrective action, including timeliness of remediation.

The costs associated with performing a corrective action alternative to achieve the target concentrations include: (a) the capital costs for designing, and constructing the alternative; (b) operation and maintenance costs; (c) costs associated with demonstrating compliance with the standards; and (d) decommissioning costs after the corrective action is completed.

The applicant should also provide a comparison among the costs associated with performing the various corrective action alternatives to achieve the target concentrations, the value of the pre-contaminated ground-water resource, and the benefits of achieving each target concentration. A proposed ACL is considered ALARA if the comparison of costs of achieving target concentrations lower that the ACL are far in excess of the value of the resource and the benefits associated with performing the corrective action alternative. If the value and benefits clearly exceed the costs or the comparison is nearly equal, the proposed ACL should be revised to the lower target concentration providing the greatest value and benefit compared to the cost.

4.3.4 Evaluation Findings

If the staff’s review, as described in SRP Section 4.3, results in the acceptance of the site hazard and ALARA assessment for ACL evaluations, the following conclusions may be presented in the TER.

> The staff has completed its review of the site and ALARA assessment for ACL evaluations at the ______________ uranium mill facility. This review included an evaluation using the review procedures in Section 4.3.2 and the acceptance criteria outlined in Section 4.3.3 of the Title II SRP.
>
> The licensee has performed an acceptable hazard assessment by considering present and potential health and environmental hazards, including cancer risk by human exposure to radioactive constituents and other health hazards resulting from the chemical toxicity of the constituents. The POE has been identified and is acceptably sited at the downgradient edge of the affected land. When a distant POE is used, written assurance has been secured, either by the licensee or NRC, that the appropriate Federal or State agency will accept the transfer of the specific property, including land in excess of that needed for tailings disposal. The hazardous constituent source term and the extent of ground-water contamination have been acceptably characterized. The transport of the hazardous constituent in ground water and surface water has been defined and any adverse effects on water quality, including present and future, have been assessed. The cancer risk and other health and environmental hazards from human or environmental exposures to hazardous constituents have been evaluated acceptably, including (a) identification of maximum levels permissible at the POC; (b) evaluation of health and environmental hazards using water classification and use standards and existing and anticipated water uses; (c) appropriate consideration of impact, based on site-specific water uses; (d) consideration of ingestion of contaminated water and food;
> (e) consideration of response of environmental and nonhuman populations to the various hazardous constituents including terrestrial and aquatic wildlife, plants, livestock, and

crops; and (f) consideration of potential damage to physical structures. The acceptable ALARA demonstration includes (1) an assessment of ground-water corrective actions dealing with identification of practicable corrective action alternatives; (2) evaluation of ability of corrective action to reduce contaminant levels appropriately; (3) demonstration that action will achieve desired concentration levels; or, as required; and (4) demonstration that practicable corrective actions are not likely to result in reduction of contamination below the proposed ACL, and that ACLs are therefore ALARA.

On the basis of the information presented in the application and the detailed review conducted of the site hazard and ALARA assessment for ACL evaluations for the _____________ uranium milling facility, the NRC staff concludes that the information is acceptable and is in compliance with the following criteria in Part 40, Appendix A: Criterion 5B, which requires NRC to establish a list of hazardous constituents, concentration limits, a POC, and a compliance period; Criterion 5C, which contains a table of secondary concentration limits for certain constituents when they are present in ground water above background concentrations; Criterion 5F, which requires that where ground-water impacts from seepage are occurring at an existing site, action must be taken to alleviate the conditions that lead to seepage, and ground-water quality must be restored, including technical specifications for the seepage control system and implementation of a QA program; and Criterion 5G, which requires licensees/operators to perform site characterization in support of a tailings disposal system proposal. The information is also in compliance with 10 CFR 40.31(f), which requires inclusion of an environmental report in the license application, and 10 CFR 51.45, which requires a description of the affected environment, containing sufficient data to aid the Commission in its conduct of an independent analysis.

4.3.5 Reference

None

4.4 GROUND-WATER CORRECTIVE-ACTION AND COMPLIANCE MONITORING PLAN

4.4.1 Areas of Review

The staff shall review any ground-water corrective-action plan that may be presented by the licensee either as a part of the RP, or as a separate licensing submittal. A separately submitted corrective-action plan will contain much of the same information that is required for the RP (e.g., a site characterization and a monitoring plan). Any information that was presented in a previously approved RP may be incorporated by reference. For review of some information, the reviewer may use review procedures in other chapters of this SRP. The following are specific portions of a corrective action plan to be reviewed:

(1) Selection of a ground-water compliance strategy,
(2) The remedial action design and implementation plan,
(3) Waste management practices,
(4) Institutional controls,
(5) Ground-water monitoring plans, and
(6) Surety.

4.4.2 Review Procedures

The reviewer shall examine corrective-action plans and compliance monitoring plan information to verify the following:

(1) The selected ground-water compliance strategy is likely to result in timely compliance with established standards.

(2) The remedial action design and the implementation plan are appropriate for the site characteristics, and clearly defined restoration cleanup standards have been determined.

(3) Waste management practices are in compliance with environmental protection regulations.

(4) Site access controls during the restoration period are sufficient to prevent significant hazards to human health and the environment.

(5) The ground-water monitoring system is sufficient to verify the performance of the selected restoration strategy, and to monitor the long-term performance of any onsite tailings disposal cells.

(6) Surface impoundment constructed as part of the program is designed to meet the requirements of 10 CFR Part 40, Appendix A criteria and are included in the dam safety program if appropriate.

4.4.3 Acceptance Criteria

In 10 CFR Part 40, Appendix A, Criterion 5D, NRC requires that if the ground-water protection standards established under paragraph 5B(1) of Part 40, Appendix A, of this criterion, are exceeded at a licensed site, a corrective-action program must be put into operation as soon as is practicable, and in no event later than 18 months after the Commission finds that the standards have been exceeded. Unless otherwise directed by the Commission, before putting the program into operation, the licensee shall submit the supporting rationale for the proposed corrective action program. The objective of the program is to return hazardous constituent concentration levels in ground water to the concentration limits set as standards. The licensee should provide an assessment of practicable corrective actions available for returning contaminant concentrations to the standards established in the license. The corrective action assessment incorporates that information and findings from the site characterization activities, which are described in SRP Section 4.1.3. Site specific characteristics may have a strong influence on which corrective action alternative will be practicable for a particular site. If additional site characterization is needed, details of the characterization plan should be included.

The corrective action should result in conformance with the established concentration limits, address either removing the hazardous constituents or treating them in place, and should include a program to monitor compliance with cleanup standards. Regulations do not require any specific designs or methods to be used for the ground-water corrective-action program. Because of the nearly limitless possibilities for designing and implementing ground-water corrective-actions, staff reviewers shall focus on the technical feasibility from an engineering perspective and evaluate whether the proposed design is likely to result in timely compliance with established concentration limits and whether the monitoring program is adequate to verify the effectiveness of the design. A ground-water corrective program or a compliance-monitoring program will be acceptable if it meets the following criteria:

(1) The ground-water compliance strategy selection is appropriate for the site.

NRC has found two strategies to be acceptable for achieving compliance with ground-water protection standards:

(a) No remediation—This is an acceptable strategy at those sites that have no ground-water contamination related to uranium processing activities, or where contamination does not exceed either background levels, MCLs, or ACLs.

(b) Active remediation—Active remediation is required when contaminants are present at concentrations above background levels, MCLs, or ACLs.

(2) The remedial action design and implementation are adequate.

When active remediation is necessary, a timetable for ground-water cleanup is established. This timetable can be based on model predictions of a design’s likely restoration performance. When models are used to predict performance, a sensitivity analysis is performed to evaluate a variety of scenarios and their effect on the expected system performance. All modeling input parameters are based on site characterization data or on technically justified assumptions.

Because there are as many potential active remediation designs as there are contaminated sites, it is beyond the scope of this SRP, and would be unnecessarily restrictive, to attempt to provide specific acceptance criteria for every possible active remediation scenario. In general, however, if active remediation methods are to be employed, a discussion of the type of active remediation is provided along with engineering specifications and an analysis of effectiveness.

Engineering specifications include design details such as pumping/injection rates, treatment methods, equipment and maintenance requirements, plans and schedules for construction, and maps showing locations of equipment.

An analysis is conducted to determine the expected effectiveness of the remediation system. Analyses are conducted to demonstrate that

(1) The chosen active remediation technology is appropriate for the hydrogeologic and geochemical conditions at the site.

(2) Design pumping rates are sustainable and sufficient to control the migration of contaminants away from the site.

(3) The effects of natural aquifer heterogeneity are properly and conservatively accounted for in the remediation strategy.

(3) Adequate waste management practices are defined.

The disposition of effluent generated during active remediation is addressed in the corrective-action plan. Appendix F (this SRP) contains NRC staff policy for effluent disposal at licensed uranium recovery facilities for conventional mills. When retention systems such as evaporation ponds are used, design considerations from erosion protection and stability along with construction plans reviewed by a qualified engineer are included. Evaporation and retention ponds should meet the design requirements of 10 CFR, Appendix A, Criteria 5A. Ideally, the ponds should have leak detection systems capable of reliably detecting a leak from the pond into the groundwater and should be located where they will not impede the timely surface reclamation of the tailings surface reclamation of the tailings impoundment.

If water is to be treated and reinjected, either into the upper aquifer or into a deep-disposal well, the injection program is approved by the appropriate State or Federal authority. If effluent is to be discharged to a surface-water body, licensees obtain a National Pollutant Discharge Elimination System permit for discharge to surface water. If plans to manage effluents are in place from earlier operations, they may be included in the corrective-action plan by reference.

(4) Appropriate site access control is provided by the licensee.

Site access control should be provided by the licensee until site closure to protect human health and the environment from potential harm. Site access is controlled by limiting access to the site with a fence and by conducting periodic inspections of the site.

(5) Effective corrective-action and compliance-monitoring programs are provided.

Licensees are required, by Criterion 7 of Appendix A to 10 CFR Part 40, to implement corrective-action and compliance-monitoring programs. The licensee’s monitoring programs are adequate to evaluate the effectiveness of ground-water restoration and control activities, and to monitor compliance with ground-water cleanup standards. The description of the monitoring program includes or references the following information:

(a) QA procedures used for collecting, handling, and analyzing ground-water samples;

(b) The number of monitor wells and their locations;

(c) A list of constituents that are sampled and the monitoring frequency for each monitored constituent;

(d) Action levels that trigger implementation of enhanced monitoring or revisions to cleanup activities (i.e., timeliness and effectiveness of the corrective action).

Corrective action monitoring

The same wells used to determine the nature and extent of contamination may be used to monitor the progress of ground-water corrective action activites. However, once the extent of contamination is delineated, it may be possible to adequately monitor compliance with fewer wells. Once selected, major changes to monitored locations are avoided, because it is important to be able to directly compare measurements made at different times.

Licensees choose a monitoring interval that is appropriate for monitoring corrective action progress. Not all hazardous constituents need to be monitored at each interval. It is generally acceptable for licensees to choose a list of more easily measured constituents that serve as good indicators of performance. These indicators include conservative constituents that are less likely to be attenuated, such as chloride, total dissolved solvents (TDSs), and alkalinity. However, if a hazardous constituent is causing a demonstrated risk to human health or the environment, that constituent must be monitored during the corrective action. Ground water at designated monitor wells is sampled for all hazardous constituents at the end of each major phase of corrective action and again before license termination and transfer of the site to the custodial agency (Department of Energy) for long-term custody.

Compliance Monitoring

After a corrective action program has been terminated, compliance monitoring at the POC will resume for the duration of the compliance period, until license termination, as defined in Appendix A.

(6) Design of Surface Impoundments

The reviewer shall determine that any lined impoundment built as part of the corrective-action program to contain wastes is acceptably designed, constructed, and installed. The design, installation, and operation of these surface impoundments must meet relevant guidance provided in Regulatory Guide 3.11, Section 1 (NRC 1977). Materials used to construct the liner shall be reviewed to determine that they have acceptable chemical properties and sufficient strength for the design application. The reviewer shall determine that the liner will not be overtopped. The reviewer shall determine that a proper quality control program is in place.

The review shall ensure that the applicable requirements of 10 CFR Part 40, Appendix A, Criterion 5(A) have been met. If the waste water retention impoundments are located below grade, the reviewer shall determine that the surface impoundments have an acceptable liner to ensure protection of ground water. The location of a surface impoundment below grade will eliminate the likelihood of embankment failure that could result in any release of waste water. The reviewer shall determine that the design of associated dikes is such that they will not experience massive failure.

The design of a clay or synthetic liner and its component parts should be presented in the application or related amendment applications for a uranium recovery operation. At a minimum, design details, drawings, and pertinent analyses should be provided. Expected construction methods, testing criteria, and quality assurance programs should be presented. Planned modes of operation, inspection, and maintenance should be discussed in the application. Deviation from these plans should be submitted to the staff for approval before implementation.

The liner for a surface impoundment used to manage uranium and thorium byproduct material must be designed, constructed, and installed to prevent any migration of wastes out of the impoundment to the subsurface soil, ground water, or surface water at any time during the active life of the surface impoundment. The liner may be constructed of materials that allow wastes to migrate into the liner provided that the impoundment decommissioning includes removal or decontamination of all waste residues, contaminated containment system components, contaminated subsoils, and structures and equipment contaminated with waste and leachate.

The liner must be constructed of materials that have appropriate chemical properties and sufficient strength and thickness to prevent failure caused by pressure gradients, physical contact with the waste or leachate, climatic conditions, and the stresses of installation and daily operation. The subgrade must be sufficient to prevent failure of the liner caused by settlement, compression, or uplift. Liners must be installed to cover all surrounding earth that is likely to be in contact with the wastes or leachate.

Tests should show conclusively that the liner will not deteriorate when subjected to the waste products and expected atmospheric and temperature conditions at the site. Applicant test data and all available manufacturers' test data should be submitted with the application. For clay liners, tests, at a minimum, should consist of falling head permeameter tests performed on columns of liner material obtained during and after liner installation. The expected reaction of the impoundment liner to any combination of solutions or atmospheric conditions should be known before the liner is exposed to them. Field seams of synthetic liners should be tested along the entire length of the seam. Representative sampling may be used for factory seams. The testing should use state-of-the-art test methods recommended by the liner manufacturer. Compatibility tests that document the compatibility of the field seam material with the waste products and expected weather conditions should be submitted for staff review and approval. If it is necessary to repair the liner, representatives of the liner manufacturer should be called on to supervise the repairs.

Proper preparation of the subgrade and slopes of an impoundment is very important to the success of the surface impoundment. The strength of the liner is heavily dependent on the stability of the slopes of the subgrade. The subgrade should be treated with a soil sterilant. The subgrade surface for a synthetic liner should be graded to a surface tolerance of less than 2.54 cm (1 in) across a 30.3-cm (1-ft) straightedge. NRC Regulatory Guide 3.11, Section 2 (NRC, 1977) outlines acceptable methods for slope stability and settlement analyses, and should be used for design. If a surface impoundment with a synthetic liner is located in an area in which the water table could rise above the bottom of the liner, underdrains may be required. The impoundment will be inspected in accordance with Regulatory Guide 3.11.1 (NRC, 1980).

To prevent damage to liners, some form of protection should be provided, such as (a) soil covers, (b) venting systems, (c) diversion ditches, (d) side slope protection; or (e) game-proof fences. A program for maintenance of the liner features should be developed, and repair techniques should be planned in advance.

The surface impoundment must have sufficient capacity and must be designed, constructed, maintained, and operated to prevent overtopping resulting from (a) normal or abnormal operations, overfilling, wind and wave actions, rainfall, or run-on; (b) malfunctions of level controllers, alarms, and other equipment; and (c) human error. If dikes are used to form the surface impoundment, they must be designed, constructed, and maintained with sufficient structural integrity to prevent their massive failure. In ensuring structural integrity, the applicant must not assume that the liner system will function without leakage during the active life of the impoundment.

Controls should be established over access to the impoundment, including access during routine maintenance. A procedure should be developed that ensures unnecessary traffic is not directed to the impoundment area.

In addition, the reviewer shall evaluate the proposed surface impoundment to determine if it meets the definition of a dam as given in Regulatory Guide 3.11 (NRC, 1977). If this is the case, the surface impoundment should be included in the NRC dam safety program, and be subject to Section 215, “National Dam Safety Program,” of the Water Resources Development Act of 1996. If the reviewer finds that the impoundment conforms to the definition of a dam, the dam ranking (low or high hazard) shall be evaluated. If the dam is considered a high hazard, an emergency action plan (EAP) is needed consistent with Federal Emergency Management Agency requirements. For low-hazard dams, no EAP is required. For either ranking of dam, the reviewer shall also determine that the licensee has an acceptable inspection program in place to ensure that the dikes are routinely checked, and that performance is properly maintained.

A quality control program should be established for the following factors: (a) clearing, grubbing, and stripping; (b) excavation and backfill; (c) rolling; (d) compaction and moisture control; (e) finishing; (f) subgrade sterilization; and (g) liner subdrainage and gas venting.

(7) Financial Surety Is Provided

The licensee must maintain a financial surety, within the specific license, for the restoration of ground water, with the surety sufficient to recover the anticipated cost and time frame for achieving compliance, before the land is transferred to the long-term custodian. The financial surety must be sufficient to cover the cost of corrective action measures that will have to be implemented if required to restore ground-water quality to the established site-specific standards (including an ACL standard) before the site is transferred to the government for long-term custody.

4.4.4 Evaluation Findings

If the staff’s review, as described in SRP Section 4.4, results in the acceptance of the ground-water corrective action plan and compliance-monitoring plans, the following conclusions may be presented in the TER:

> The staff has completed its reviw of the ground-water corrective-action and compliance-monitoring plans at the ____________ uranium mill facility. This review included an evaluation using the review procedures in Section 4.4.2 and the acceptance criteria outlined in section 4.4.3 of the Title II SRP. The ground-water corrective action program should achieve the goal of returning hazardous constituent concentration levels in ground water to the concentration limits set as standards (Part 40, Appendix A, Criterion 5D). The monitoring program will provide reasonable assurance that after the corrective actions have been taken, the ground-water protection standard will not be exceeded.
>
> The licensee has established a ground-water compliance strategy that is acceptable for the site. The strategy consists either of no remediation or active remediation when contaminants are present at concentrations above background levels, MCLs, or ACLs. When active remediation is necessary, the remedial action design and implementation are

acceptable. The licensee has acceptably presented pumping/injection rates, treatment methods, equipment and maintenance requirements, and plans and schedules for construction, and has produced maps showing locations of remediation equipment. An analysis has been conducted that demonstrates (1) the chosen active remediation system technology is appropriate for the site conditions, (2) design pumping rates are sustainable and will control migration of contaminants away from the site, and (3) the natural heterogeneity of the system has been acceptably accounted for in a conservative remediation strategy. The licensee has identified acceptable waste management practices. Qualified engineers, State authorities, and national agencies have provided appropriate oversight. Institutional controls are appropriate for the site, including (1) controlling access to the site, (2) conducting periodic inspections, and (3) periodically monitoring restoration performance. The monitoring program includes (1) a description of QA procedures, (2) the number of monitoring wells and their locations, (3) a list of constituents that will be sampled, along with the sampling frequency for each monitored constituent, and (4) action levels for triggering enhanced monitoring or revisions to cleanup activities. The licensee has described an acceptable scheme for restoration and compliance monitoring. The licensee will sample ground water at the POC for all hazardous constituents of concern.

On the basis of the information presented in the application and the detailed review conducted of the groundwater corrective-action and compliance-monitoring plans for the _____________ uranium mill facility, the NRC staff concludes that the information is acceptable and are is in compliance with the following criteria in Part 40, Appendix A: Criterion 5B, which requires NRC to establish a list of hazardous constituents, concentration limits, a POC, and a compliance period; Criterion 5C, which provides a table of secondary concentration limits for certain constituents when they are present in ground water above background concentrations; Criterion 5E, which requires licensees conducting ground-water protection programs to consider the use of bottom liners, recycle of solutions and conservation of water, dewatering of tailings, and neutralization to immobilize hazardous constituents; Criterion 5F, which requires that where ground-water impacts from seepage are occurring at an existing site, action must be taken to alleviate the conditions that lead to seepage, and ground-water quality must be restored, including providing technical specifications for the seepage control system and implementation of a QA program; Criterion 5G, which requires licensees to perform site characterization in support of a tailings disposal system proposal; Criterion 5H, which requires steps be taken during stockpiling of ore to minimize penetration of radionuclides into underlying soils; Criterion 7A, which provides for establishment of three types of monitoring systems: detection, compliance, and corrective action; and Criterion 13, which provides a list of hazardous constituents that must be considered when establishing the list of hazardous constituents in ground water at any site.

If surface impoundments are to be used at the facility to manage byproduct material, the design of dikes used to construct surface water impoundments has been demonstrated to comply with Regulatory Guide 3.11, Sections 2 and 3 (NRC, 1977) and, therefore, comply with requirements of 10 CFR Part 40, Appendix A, Criterion 5(A)5. In addition, because the impoundment dikes may conform to the definition of a dam as given in the Federal Guidelines for Dam Safety, they are subject to the NRC dam safety program, and to Section 215, "National Dam Safety Program, of the Water Resources Development Act of 1966".

4.4.5 References

Nuclear Regulatory Commission. 1977. "Design, Construction, and Inspection of Embankment Retention Systems for Uranium Mills." Regulatory Guide 3.11. Washington, D.C.

Nuclear Regulatory Commission. 1980. "Operational Inspection and Surveillance of Embankment Retention Systems for Uranium Mill Tailings." Regulatory Guide 3.11.1, Revision 1. Washington, D.C.

5.0 RADIATION PROTECTION

This chapter of the Standard Review Plan (SRP) establishes the guidelines for NRC staff to perform and document its review of the proposed radiation protection design for disposal cell covers, for the cleanup of soil and structures contaminated with byproduct material (soil removal, building demolition and disposal, or decontamination), and for the radiation safety controls and monitoring necessary during reclamation and decommissioning activities. The radiation standards to be addressed in the evaluation of the reclamation plan (RP) include 10 CFR Part 40, Appendix A, Criterion 6(1) requiring a long-term radon flux limit and direct gamma exposure at background levels for the tailings disposal cell cover, and Criterion 6(5) requiring that the radioactivity of near-surface cover materials be essentially the same as surrounding surface soils. Also, the decommissioning plan, whether submitted as part of the RP or provided in detail as a separate document, should comply with §40.42(g)(4) and (5). This would include a description or procedures indicating how the licensee will demonstrate that the residual radioactivity levels in land and on structure surfaces meet Appendix A, Criterion 6(6) (see Appendix H guidance in this SRP on the radium benchmark dose approach for cleanup of residual radionuclides). In the review, the staff will consider any licensee-proposed alternatives to Appendix A criteria as described in the Introduction of Appendix A to Part 40.

5.1 COVER RADON AND GAMMA ATTENUATION AND RADIOACTIVITY CONTENT

5.1.1 Areas of Review

The areas of review for radon attenuation (radon barrier design) are the radiological and physical properties of the contaminated and cover materials and the application of the computer code or other methods used for calculating the estimated long-term radon flux from the completed disposal cell. The areas of review for the control of gamma radiation from the tailings and for the radioactivity content of the cover are the proposed methods to demonstrate compliance with the regulations.

For the radon barrier design of the tailings disposal cell, the staff will review (1) the bases, assumptions, and procedures for determining the input parameter values of the tailings and radon barrier materials (such as the sampling and testing programs); (2) procedures for materials placement in the disposal cell, as presented in the RP construction specifications; (3) the description of the model (numerical or analytical) used to approximate the average long-term radon flux at the cover surface; and (4) if the standard computer codes for estimating radon flux (RADON, RAECOM) are not used, references for the methodology used to calculate the long-term radon flux from the cover.

For the gamma attenuation of the cover, the staff reviews the proposed procedure to calculate or measure the gamma level (exposure rate or count rate) on the cover. For the radioactivity content of the cover, review the proposal for measurements in the upper 61 cm (2 ft) of cover or for control measures on the cover material before placement to demonstrate that the average radioactivity content of this layer is not distinguishable from local surface soil and to demonstrate that it does not include waste or rock containing elevated levels of radium.

5.1.2 Review Procedures

5.1.2.1 Radon Attenuation

The radon barrier design, as presented in the RP, will be reviewed along with the data supporting the design. Chapter 2.0 of this SRP presents review areas, procedures, and acceptance criteria for geotechnical information related to material properties and cell stability. The staff members assigned the health physics and geotechnical reviews will coordinate the review of the radon attenuation design and analysis. The geotechnical properties of the cover layers will be considered in the context of their influence on the integrity (e.g., settlement, biointrusion, and freeze-thaw events) and long-term moisture content of the radon barrier. Materials underlying the radon barrier are evaluated for stability so that the cover will not experience cracking from settlement or subsidence, as discussed in Chapter 2.0. The reviewer also assesses the properties of offsite materials for those sites that have large volumes of offsite material that will be placed in the disposal cell.

In addition, the H.P. reviewer will

(1) Evaluate the basis for selection of parameter values for tailings and cover material properties to determine if the values are based on appropriate measurements or estimates and will lead to a reasonably conservative estimate of the radon flux. The scope and techniques used for site investigations should be examined to ensure that the field investigation (boring, sampling, and surveying) and testing programs will produce representative data needed to support the conclusions of the analyses.

(2) Assess whether parameter values are consistent with anticipated construction specifications and reflect expected long-term conditions at the site. The radon flux estimate must represent the average for periods of more than 1 year but less than 100 years, and consider that the cell design life is 1000 years; thus the emphasis on long-term conditions for parameter values.

(3) Determine whether the parameter values reflect the meteorological and hydrological conditions at the disposal site, bulk density, type of material, and the influence of overlying material layers. The moisture content must be determined by accurately measured values or reasonably conservative estimates. Preferably more than one method is utilized as there are limitations to each method and the long-term moisture content of the radon barrier is one of the most important parameters in the flux model.

(4) Determine that the value of the radium (Ra-226) activity concentration in picocuries per gram (pCi/g) within the tailings cell has been or will be measured directly from representative tailings samples and other large-volume sources of contaminated material utilizing an acceptable method. If the tailings were placed so that specific areas in the pile contain higher Ra-226 content (e.g., slime tailings), then Ra-226 values and the modeling should represent the layering or localization of the significantly elevated Ra-226 levels in the upper 3.6 m (12 ft), as deeper material has little effect on the radon flux. This approach is necessary because modeling higher concentrations of Ra-226 in the upper few feet of the pile would result in a higher radon flux estimate than using an average Ra-226 value for the entire upper 3.6 m (12 ft). Also, if large quantities of material containing thorium-230 (Th-230) levels significantly higher than the Ra-226 levels are placed in the upper portion of the pile, the 1000-year Ra-226 concentration (Ra-226 remaining from the residual Ra-226 and from the decay of Th-230) should be used for that layer of material in the modeling.

In accordance with footnote 2 of Criterion 6(1), the radon emissions from covering materials should be estimated as part of developing a closure (reclamation and decommissioning) plan. If any layer of the cover will contain material with above-background levels of Ra-226 or Th-230, the licensee should model that layer with a conservatively high estimated Ra-226 level, or should commit to measure the cover radionuclide level(s) during or after placement to confirm the adequacy of the radon attenuation design. A commitment from the licensee to confirm the cover Ra-226 content in the reclamation completion report should be present if the borrow site measurements are limited and the possible cover Ra-226 level could prevent the radon flux from being in compliance.

(5) Evaluate each code input parameter value, keeping in mind that the code default parameter values are not always conservative, and then consider the set of parameter values as a whole (balance of conservatism and uncertainty). It is the total flux model that will be approved, not individual parameter values. Consider that the void ratio, the density, porosity, and moisture saturation values should be typical of the soil type in each layer of the cell. The radon flux model should result in a representative and a reasonably conservative (given the uncertainty in some values) long-term radon flux estimate.

(6) A measured, not a calculated, disposal cell average radon flux is required by Appendix A, Criterion 6(2), as soon as practical after placement of the radon barrier and Criterion 6(3) stipulates that radon-222 release rates must be verified for each portion of the pile or impoundment as the final radon barrier for that portion is placed, when phased emplacement of the final radon barrier is included in the applicable RP. Therefore, the reviewer should document in the TER whether the RP stipulates if the radon barrier is to be placed in phases or as a fairly continuous operation.

5.1.2.2 Gamma Attenuation

Most radon barriers should be thick enough to reduce the gamma level of the disposal cell to background. To demonstrate compliance with this aspect of Criterion 6(1), the cover gamma attenuation is calculated based on the shielding value of the cover soil. Alternatively, the licensee commits to (1) measure the gamma level at 1 meter above the completed cover (or radon barrier) with at least one measurement per acre and (2) demonstrate that the average gamma level for the cell is comparable to the local background value.

5.1.2.3 Cover Radioactivity Content

At some mill facilities, uranium deposits, open pit uranium mines, overburden piles (soil moved from the pit area), and/or reclaimed mining areas are on or near the site. All of these areas would contain elevated levels of uranium, radium, and the other radionuclides in the uranium decay chain. In determining what surrounding soil values may be compared to the radionuclide content of the disposal cell cover, the mining areas reclaimed/restored under State regulations may be included. Also, consideration of the low health risk of human exposure to the cell cover and the perpetual custody of the cell by the government may be used in the risk-informed approach. If the average radioactivity value (mainly radium and uranium) for the cover material exceeds the average value for surrounding soil, the RP should contain a statistical analysis of the distributions of surrounding soil (not necessarily background) and cover radioactivity values to demonstrate that they are not significantly different.

5.1.3 Acceptance Criteria

5.1.3.1 Radon Attenuation

The radon attenuation design will be acceptable if it meets the following criteria:

(1) The one-dimensional, steady-state gas diffusion theory for calculating radon flux and/or minimum cover thickness is used. An acceptable analytical method for determining the necessary cover thickness to reduce radon flux to acceptable limits or to determine the long-term radon flux from the proposed cover is the computer code RAECOM (NRC, 1984) and the comparable RADON code (NRC, 1989). The main difference between the two codes is that RADON does not have an optimization for cost-benefit. The staff will use the RADON code to verify the analysis. Other methods that estimate the average surface radon release from the covered tailings may be acceptable, if it can be shown that these methods produce reliable estimates of radon flux.

(2) With the RAECOM and RADON computer codes, the radon concentration above the top layer is either set to a conservative value of zero or a measured background value is used. The precision number (the level of computational error that is acceptable) is set at 0.001.

(3) The estimates of the material parameters used in the radon flux calculations are reasonably conservative, considering the uncertainty of the values. For all site-specific parameters, supporting information describing the test method and its precision, accuracy, and applicability is provided. The basis for the parameter values and the methods in which the values are used in the analyses are adequately presented. Moisture-dependent parameter values are based on the estimated long-term moisture content of the materials at the disposal site (e.g., radon emanation coefficient and diffusion coefficient).

The materials testing programs employ appropriate analytical methods and sufficient and representative samples were collected to adequately determine material property values for both cover soils and contaminated materials. In the absence of sufficient test data, conservative estimates are chosen and justified. The quality assurance program for parameter data is adequate and the data will be available for inspection. All parameter values are consistent with anticipated construction specifications and represent expected long-term conditions at the site.

(4) The estimate of the tailings thickness is determined from estimates of total tailings production and the tailings areal extent, from boring logs, or changes in elevation from pre- to post-operation. Either the estimated thickness of a tailings source is used, or alternatively, the RADON code default value of 500 cm (16.4 feet) is used (NRC, 1989).

(5) Dry bulk densities of the cover soils and tailings material are determined from Standard Proctor Test data (ASTM D 698) or Modified Proctor Test data (ASTM D 1557). Radon barrier materials are usually compacted to a minimum of 95 percent of the maximum dry density as determined by ASTM D 698 or to a minimum of 90 percent of the maximum dry density as determined by ASTM D 1557. Field or placement densities to be achieved following the construction specifications are used in the calculations. If the pile is stabilized in place, the in situ bulk density for the tailings is used in the analysis.

Porosities are measured by mercury porosimetry or another reliable method, or the method for estimating the porosity of cover soils and tailings materials using the bulk density and specific gravity given in Regulatory Guide 3.64 (NRC, 1989) is used.

If a portion of the modeled cover could be affected by freeze-thaw events, that portion is represented in the model with lower density and corresponding higher porosity values than the unaffected portion. The US Army Corps of Engineers (ACE, 1988) and the Department of Energy (DOE, 1988) have demonstrated that freeze-thaw cycles can increase the permeability of compacted clay by 40 to 300 times the original value. For fine-grained soils with some sand (50 percent fines), the DOE conservatively estimated that freeze-thaw cycles could lower the density by 14 percent (DOE, 1992). Also see the discussion in Section 2.5.3 of this SRP.

(6) The long-term moisture content that approximates the lower moisture retention capacities of the materials or another justified value is used. Estimated values for the long-term moisture content can be compared with present in situ values to assure that the assumed long-term value does not exceed the present field value. Borrow samples can be taken at a depth of 120 to 500 cm (3.9 to 16.4 feet), but not close to the water table, and the borrow site conditions should be correlated to conditions at the disposal site are acceptable.

The following methods are acceptable for estimating the long-term soil moisture, but each has limitations:

(a) Laboratory procedures ASTM D-3152 (fine-textured soils) and ASTM D-2325 (coarse and medium-textured soils) for capillary moisture test (15-bar suction) corresponding to the moisture content at which permanent wilting of plants occurs (Baver, 1956); and

(b) The empirical relationship (Rawls and Brakensiek, 1982) that predicts water- retention values of a soil on a volume basis, (appears to be more suitable to sandy and silty soil) and is represented by

$$c = 0.026 + 0.005x + 0.0158y$$

where
c = predicted 15-bar soil water-retention value
x = percent clay in the soil
y = percent organic matter in the soil

This method takes into consideration the particle-size distribution of the soil. Clay particle sizes are defined here as those less than 0.002 mm in diameter. Organic content measurement is generally determined by reaction with hydrogen peroxide or by exposure to elevated temperature. The volumetric moisture content value derived from this equation should be converted to a weight percentage for application in the RAECOM and RADON codes. Other empirical correlations (Section 7.1.3 of DOE, 1989), if adequately justified, may be acceptable.

(7) Values for Ra-226 activity (pCi/g) are measured directly from tailings samples and other large-volume sources of contaminated material by the radon equilibrium gamma spectroscopy (allow at least 10 days for the sealed sample to equilibrate, wet chemistry alpha spectrometry, or an equivalent procedure. If the tailings are fairly uniform in Ra-226 content and the Ra-226 and Uranium (U-238) in the ore were approximately in equilibrium, the Ra-226 activity can be estimated from the average ore grade processed at the site, as discussed in Regulatory Guide 3.64 (NRC, 1989). Generally, tailings should be sampled at 60- to 90-cm (2- to 3-foot) intervals to a depth of 366 cm (12 feet), including representative sampling of slime tailings. More than one layer of contaminated material is represented in the flux model if there are significant differences in Ra-226 content with depth.

Since the disposal cell performance standard deals only with radon generated by the contaminated material, it is acceptable to neglect the Ra-226 activity in the cover soils for modeling flux, provided the cover soils are obtained from materials not associated with ore formations or other radium-enriched materials. If deep (below 2 feet (61 cm)) cover layers contain elevated Ra-226 or Th-230, that material layer is represented in the flux model.

(8) The emanation coefficient has been obtained by using methods provided in Nielson et al. (1982) and properly documented, or otherwise set to the reasonably conservative (for most soils) code default value of 0.35. A value of 0.20 may be estimated for tailings based on the literature, if supported by limited site-specific measurements.

(9) The radon diffusion coefficient, D, represents the long-term properties of the materials. The D value can be determined from direct measurements. The soil should be tested at the design compaction density, with a range of moisture content values that includes the lower moisture retention capacity of the soil so that a radon breakthrough curve can be obtained (DOE, 1989). The calculation of diffusion coefficient, based on the long-term moisture saturation, and porosity, as proposed in Regulatory Guide 3.64, Section C.1.1.5 (NRC, 1989) and the optional calculation in the RADON code, is acceptable.

(10) The estimated soil cover thickness in the reclamation design is such that the calculated average long-term radon flux is reduced to a level that meets the requirement in 10 CFR Part 40, Appendix A, Criterion 6(1).

5.1.3.2 Gamma Attenuation

The proposed cover will reduce the gamma radiation from the byproduct material to background levels. This will be adequately demonstrated by data to appear in the reclamation completion report.

5.1.3.3 Cover Radioactivity Content

At least the upper 2 feet (61 cm) of the disposal cell cover will contain levels of radioactivity essentially the same as surrounding soils, as demonstrated by an appropriate procedure. The data will be in the reclamation completion report if not available for the RP.

5.1.4 Evaluation Findings

If the staff’s review, as described in this section, results in the acceptance of the radon and gamma attenuation and cover radioactivity content assessments, the following conclusions may be presented in the technical evaluation report (TER):

> The staff has completed its review of the disposal cell cover radiation control at the _____________ uranium mill facility. This review included an evaluation using the review procedures in Section 5.1.2, and the acceptance criteria outlined in Section 5.1.3 of the Title II SRP.
>
> The licensee has presented an acceptable radon attenuation design and the staff evaluation determines that (1) the method used for calculating radon flux or minimum cover thickness is based on the one-dimensional, steady-state gas diffusion theory and appropriate input values; (2) input values of the material parameters lead to a reasonably conservative estimate of the long-term radon flux; (3) material parameters are consistent

with construction specifications and expected long-term conditions; (4) the long-term attenuating capability of cover materials is justified using acceptable results of relevant tests or conservative estimates; (5) estimates of contaminated materials thickness are determined from estimates of total tailings production and the areal extent of tailings, or borehole exploration, utilizing a sufficient number of data or by use of the default value; (6) if not measured, the estimated porosity of cover soils and tailings materials is based on the method in Regulatory Guide 3.64; (7) soil moisture values represent conservative long-term moisture retention capacities; (8) Ra-226 activity has been measured in the tailings and other large-volume sources of contaminated materials using acceptable procedures; (9) the emanation coefficient is obtained by either the equilibration method or the prediction method, or is set to a reasonably conservative value of 0.35; (10) the radon diffusion coefficient of the cover soil is determined from direct measurements or from a calculation based on Regulatory Guide 3.64; and (11) the cover gamma level and radioactivity content will meet regulatory levels and will be correctly determined and documented.

On the basis of the information presented in the application and in detailed review conducted of the site characterization for the _____________ uranium mill facility, the NRC staff concludes that the radon attenuation design is acceptable and is in compliance with 10 CFR Part 40, Appendix A, Criterion 6(1). This criterion requires placement of an earthen cover (or approved alternative) over tailings or wastes at the end of the milling operations while providing assurance of control of radiological hazards for a 1000 years, to the extent reasonably achievable (but no less than 200 years); and which limits releases of radon-222 from uranium byproduct materials to the atmosphere so as not to exceed an average rate of 20 picocuries per square meter per second (pCi/m2-s) to the extent practicable throughout the effective design life. Also, the proposed method of demonstrating reduction of gamma levels to background is acceptable for compliance with Criterion 6(1). The proposed procedures to ensure that near surface cover materials contain essentially the same radioactivity as surrounding surface soils and do not include waste or rock that contains elevated levels of radium should provide results that demonstrate compliance with Criterion 6(5).

5.1.5 References

American Society for Testing and Materials (ASTM) Standards:

D 698-91, "Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort."

D 1557-91, "Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort."

D 2325-68, "Standard Test Method for Capillary-Moisture Relationships for Coarse- and Medium-Textured Soils by Porous-Plate Apparatus."

D 3152-72, "Standard Test Method for Capillary-Moisture Relationships for Fine-Textured Soils by Pressure-membrane Apparatus."

Army Corps of Engineers. 1988. "Effects of Freezing and Thawing on the Permeability of Compacted Clay." Hanover, New Hampshire: Cold Regions Research and Engineering Laboratory.

Baver, L.D. 1956. Soil Physics. New York: John Wiley and Sons, pp. 283-303.

Department of Energy. 1988. “Effect of Freezing and Thawing on UMTRA Covers.” Uranium Mill Tailings Remedial Action Project. Albuquerque, New Mexico.

Department of Energy. 1989. “Technical Approach Document, Revision II.” UMTRA-DOE/AL 050425.0002. December 1989.

Department of Energy. 1992. “Remedial Action Plan and Site Design for Stabilization of the Inactive Uranium Mill Tailings Site at Gunnison, Colorado. Remedial Action Selection Report.” UMTRA-DOE/AL-050508. October 1992.

Nielson, K.K., et al. 1982. “Radon Emanation Characteristics of Uranium Mill Tailings.” Proceedings of the Symposium on Uranium Mill Tailings Management December 9-10, 1982. Ft. Collins, Colorado: Colorado State University.

Nuclear Regulatory Commission. 1984. “Radon Attenuation Handbook for Uranium Mill Tailings Cover Design.” NUREG/CR-3533. Washington, D.C.

Nuclear Regulatory Commission. 1989. “Calculation of Radon Flux Attenuation by Earthen Uranium Mill Tailings Covers.” Regulatory Guide 3.64. Washington, D.C.

Rawls, W.J., and D.L. Brakensiek. 1982. “Estimating Soil Water Retention From Soil Properties.” Journal of the Irrigation and Drainage Division. Proceedings of the American Society of Civil Engineers 108(IR2).

5.2 DECOMMISSIONING PLAN FOR LAND AND STRUCTURES

5.2.1 Areas of Review

The areas of review for the decommissioning (radiological cleanup) of land and structures such as buildings are the site conditions (nature and extent of the contamination, soil background radioactivity, etc.); planned decommissioning activities (how and what measurements will be made, quality assurance quality control program, gamma guideline levels for soil cleanup, how “as low as is reasonably achievable” (ALARA) will be demonstrated); methods to be used to protect workers, the public, and the environment; verification (final status survey) plans or procedures; and the decommissioning cost estimate. Often, the detailed mill decommissioning plan and the soil cleanup and verification plan are submitted for NRC approval in the year before decommissioning begins. However, the RP must describe the expected decommissioning activities in enough detail to support the cost estimate needed for surety purposes. The preliminary decommissioning plan in the RP should include commitments to provide detailed plans and procedures for NRC approval at least 9 months before decommissioning begins.

5.2.2 Review Procedures

(1) Site Conditions

Based on the operational history (including radiation surveys) of the facility, the reviewer should determine that the plan describes the likely source and locations of residual byproduct material such as, spills, releases, waste burial, haul roads, diversion ditches, process and yellowcake storage areas, ore stockpile areas, areas likely to be affected by windblown tailings, and tailings solution evaporation ponds. Determine that the extent of contamination (area and depth for soil) has been or will be established from adequate representative sampling and surveying. Sample analysis should include uranium where yellowcake or ore dust was present and thorium (Th-230) for acidic pond residue. The radiological analysis for the ore processed at the site should also be reviewed for the ratios of Ra-226/U-238 and Ra-226/Th-230 to determine if non-equilibrium conditions could exist in the contaminated soil. The U-238 activity can be estimated by dividing the U-nat (total uranium) value by two. The reviewer should also determine from this data if Th-232 could be elevated above background due to windblown tailings and whether additional characterization data should be provided.

(2) Soil Background Radioactivity

Determine that the background level of Ra-226 (U-nat, Th-230 and Th-232, as needed) in surface (15 cm (6 in)) soil has been determined using representative soil samples from nearby (within 3.2 km (2 mi) of site boundary) undisturbed areas not affected by site activities that are geologically and chemically similar to the contaminated areas. The number of samples will depend partly on the variability in background values but at least 30 samples should be obtained at the typical site to determine the average value, standard deviation, and distribution. The arithmetic mean is used in the cleanup criteria unless appropriate statistical analysis demonstrates a log normal distribution (three tests) of the data.

Several different background values may be required if contaminated areas have distinctly different soil types. For example, if a portion of the site has a natural uranium and/or radium mineralization zone in/near the surface, the cleanup criterion for that area would use a background (reference) U-238 or Ra-226 value from a similarly mineralized area. A geologic site map with the background values placed on the sample location, if available, can be used to help identify if more than one background value should be considered.

If the plan indicates that in situ ore is in the area, it should be characterized by Ra-226/U-238 ratios, visual criteria, and/or other means.

(3) Cleanup Requirements

For land cleanup, the residual radium (Ra-226 and/or Ra-228 if thorium (Th-232) byproduct material is present) in soil must meet the concentration limits in Part 40, Appendix A, Criterion 6(6), in areas that are not evaluated by the radon flux criterion (i.e., areas other than the disposal cell). If the plan indicates that the subsurface 15 pCi/g Ra-226 standard will be used, its use should be justified. For structures to remain on site, the staff reviews the proposed cleanup of mill-related radionuclides (byproduct material) on surfaces as well as in underlying soil.

For NRC uranium recovery (UR) licensees that did not have a decommissioning plan approved by June 11, 1999 (Appendix A, Criterion 6(6) was expanded effective that date), or that subsequently submit a revised plan, the radium benchmark dose applies for cleanup of residual radionuclides other than radium (primarily uranium (U-nat values/2 approximates U-238 activity) and thorium (Th-230)) in soil and for surface activity on structures. For such licensees, the reviewer should refer to Appendix H of this document for guidance on the benchmark approach. This approach would also be evaluated if proposed by other UR licensees to derive cleanup limits in order to demonstrate compliance with §40.42(k)(2).

Determine that the plan includes proposed ALARA levels. Usually a low gamma guideline level is chosen so that most grids are cleaned to near background levels of radiation, an approach that has proven less costly for licensees than compared to more extensive soil sampling and analysis. It is a method acceptable to the staff to demonstrate compliance with the ALARA principle. The administrative limit for surface activity (10-25 percent of the criteria) has been considered an ALARA level in the past but current policy should be confirmed by staff. The ALARA approach discussed in draft Regulatory Guide DG-4006 (NRC, 1998c), also may be considered.

(4) Gamma Guideline Level

Because gamma measurements (in terms of exposure or count rates) can substitute for some Ra-226 analyses [as recommended in 40 CFR 192.20(b)(1)] and such measurements are not very reliable, the reviewer must be sure that the proposed gamma guideline value is conservative considering the measurement uncertainties involved. Determine that the radium-gamma correlation that is used to derive the gamma guideline was performed with at least 30 soil Ra-226 values from 2 to 25 pCi/g and that the corresponding gamma values adequately represent the grid (100 square meter area) sampled. The proposed gamma guideline level must reliably (95 percent confidence) result in grids meeting the 5 pCi/g (0.19 Bq/g) Ra-226 plus background standard.

Confirm that the plan contains a commitment to perform a radium-gamma correlation on the verification data, to track soil samples that fail the Ra-226 criteria, and to perform additional cleanup after a verification soil sample exceeds the Ra-226 standard. Just cleaning the failed grid is not adequate because the failed sample could indicate that the gamma value may not be conservative and that some of the unsampled grids may also fail to meet the standard. For example, the plan could indicate that neighboring grids would also be analyzed for Ra-226 or if the number of failed grids is excessive, the gamma guideline would be adjusted downward and areas further remediated, as necessary.

(5) Instruments and Procedures

Determine that the instruments and procedures used to determine the soil background radioactivity and the radium-gamma correlation are the same or very similar to those proposed for verification of compliance with Criterion 6(6) (final status survey). See NUREG-1505, Section 4.5 (NRC, 1998a). Instrument sensitivity should be adequate to reliably identify the proposed guideline levels (NUREG-1507, NRC, 1998b). Survey instruments are specified and will be properly calibrated and tested (e.g., daily checks during operations). The reviewer considers national standards (ASTM, ANSI, and NCRP as listed in Section 5.2.5) and the "Multi-Agency Radiation Survey and Site Investigation Manual" (NUREG-1575, NRC, 1997b) that contains general principles of soil sampling, determination of background, and gamma surveying.

Soil samples for UR sites can be composite samples (5 to 11 samples per grid have been approved). Evaluate sampling procedures for completeness (ensure proper depth, identification of sample and location, cleaning of equipment, chain-of-custody, etc). Determine that soil preparation procedures indicate that rocks and vegetation should not be included in the sample to the extent that the additional volume would dilute the soil sample. Generally, it is acceptable to exclude rocks greater than or equal to 1.27 cm (0.5 in) in diameter. Acceptable sample mixing, drying, and splitting methods are specified.

Evaluate the methods for soil radionuclide analysis. Standard analytical methods should be used. Portions of each sample verifying compliance should be archived until the NRC approves the decommissioning completion (final survey) report, as staff may want to do confirmatory analysis on selected soil samples. The plan for the final disposal of these archived samples should also be reviewed.

As required by §40.42(j)(2)(i), the gamma levels to be reported in the final survey are as mSv (FR) per hour at 1m from the surface. Measurements at 1 m would allow calculation of an exposure dose but the goal of the gamma survey is to demonstrate compliance with the radium in soil criterion. Therefore, the staff has approved alternative methods such as meter readings (counts/minute) taken near the ground or at 0.45 m (18 inches). These methods improve the quality of the gamma-radium correlation by reducing "shine" and allow the survey meter and equipment associated with a global positioning system to be mounted on an all-terrain vehicle. Typically, measurements are made over the spot to be sampled or the grid 100 m^2 is scanned with 9 to 12 measurements. Integrated count rate gamma scan values have also been approved if taken for at least one minute within each grid.

Determine that gamma survey procedures indicate the speed, pattern, and spacing of the measurements or scan path. The procedure should allow demonstration of compliance with the radium standard. The reviewer will consider the thoroughness of the gamma scan (remedial action survey) to be done during soil removal (such as 1.5 m (5-foot) scan path) when evaluating the final survey procedures.

Determine that procedures for measuring alpha or beta-gamma radiation on structure surfaces are detailed, reflect industry standards, and consider that smears for alpha activity generally have an efficiency of 10 percent or less. Measurements of smears are difficult to interpret quantitatively and should not be used for determining compliance but for determining if further investigation is necessary (NUREG-1575, Sections 6.4.2 and 8.5.3, NRC, 1997b).

(6) Quality Assurance and Quality Control

Determine that the quality assurance/quality control program addresses all aspects of decommissioning. The plan should indicate a confidence interval or that one will be specified before collection of samples. At least 10 percent of the soil samples should be split and a portion sent to an outside laboratory for quality assurance. To properly assess the adequacy of radiological data, the uncertainties associated with the data should be estimated statistically (NUREG-1501, Sections 3.2 and 5.2, NRC, 1994).

Evaluate the criteria for validating that the data to be used to demonstrate compliance and the quality assurance procedures to confirm that compliance data are precise and accurate (e.g., laboratory sent spiked and duplicate samples, etc.). Confirm that management will insure that approved procedures are followed (e.g., commitment to check gamma surveyor and data management).

(7) Final Status Survey

Evaluate the details of the proposed final status survey (radiation surveys and soil analyses) as discussed in items 3-6 above, and determine that the survey plan complies with §40.42(j)(2). The reviewer should also determine that enough data of the proper quality can be provided after decommissioning to demonstrate compliance with Criterion 6(6) of Appendix A and §40.42(k)(2). For example, determine that the proposed number and pattern of grids to be soil sampled and analyzed for Ra-226 are justified. Based on the degree of uncertainty (level of error in the measurements, number of measurements), the gamma guideline level, and implementation procedures, the staff has considered soil samples from 0.5 to 10 percent of the grids acceptable. Some verification soil sampling and surveying should be planned in presumably uncontaminated areas (buffer zone of about 30 meters around excavated areas). (Refer to Section 3 in Inspection Procedure 87654, (NRC, 1997a) for additional information.

Confirm that the licensee proposes to use the same instruments and procedures for the verification (final status) survey as were used in determining background and for the radium-gamma correlation, or justifies that they are comparable.

If buildings or the structures are to remain on site after license termination, determine that adequate measurement of the surface activity is planned. Preliminary modeling by staff has indicated that for habitable buildings the average total (fixed plus removable) alpha level should be below 2000 dpm/100 cm^2 in order to achieve 0.25 mSv/yr (25 mrem/yr).

(8) Preliminary Versus Final Decommissioning Plan

A preliminary decommissioning plan may be submitted with the reclamation plan and license application or license renewal in order for the staff to evaluate the cost estimate provided for surety purposes. Since the actual site decommissioning may be years in the future and continued operation could change the cleanup design, or evolving technology and Agency rules or guidance could change the evaluation of procedures, the review of the preliminary plan is less rigorous on technical aspects. However, determine that sufficient detail has been provided in the plan to determine if the surety amount for decommissioning activities is adequate.

Confirm that the plan identifies a location to keep the records of information important to the decommissioning as required by §40.36(f). These records would include documentation of spills or cleanup of contamination, drawings or descriptions of modification of structures in the restricted area, and locations of possible inaccessible contamination.

When a final decommissioning plan is submitted, the reviewer determines that the plan addresses the technical aspects discussed above (basically §40.42(g)(4) requirements) and it indicates that decommissioning will be completed as soon as practicable. The reviewer follows Section 5.3 of this SRP for the evaluation of the health and safety protection aspects of decommissioning. The reviewer also considers recommendations in Regulatory Guide 3.65 (NRC, 1989) during the evaluation of the final decommissioning plan.

(9) Non-Radiological Hazardous Constituents

The decommissioning plan must address the nonradiological hazardous constituents of the byproduct material according to Criterion 6(7). For windblown tailings areas, meeting the surface Ra-226 standard should be adequate to control these constituents. A tailings cell cover that meets Appendix A criteria should control, minimize, or eliminate post-closure escape of non-radiological hazardous constituents into surface water and the atmosphere. However, any unusual or extenuating circumstances related to such constituents should be discussed in the RP or decommissioning plan in relation to protection of public health and the environment and evaluated by staff. The control of these substances in ground water is evaluated under Chapter 4.0 of this SRP.

(10) Decommissioning Cost Estimate

Determine that the cost estimate is itemized in sufficient detail that values for soil sampling and preparation, Ra-226 analysis, gamma surveying, data management, etc. are presented. The items reflect the proposed activities in the plan. Also, the basis for each cost is provided and can be verified by staff as within the range of current charges for such activities in the site region.

5.2.3 Acceptance Criteria

The decommissioning plan will be acceptable if it meets the following criteria:

(1) The plan contains procedures to identify and place within the disposal cell, all soils on and adjacent to the processing site that are in excess of the standards in Part 40, Appendix A, Criterion 6(6), due to site activities. The plan is substantiated by the radiological characterization data and site history.

(2) Appropriate soil background values (different geological areas may need separate background values) for Ra-226, and for U-nat, Th-230, and/or Th-232 as appropriate, have been proposed with supporting data.

(3) If elevated levels of uranium or thorium are expected to remain in the soil after the Ra-226 criteria have been met, the licensee has used the radium benchmark dose approach in Appendix H for developing decommissioning criteria.

(4) To ensure consistency of measurements, instrumentation and procedures used for soil background analyses and the Ra-gamma correlation are the same or very similar to those proposed to provide verification data. The instrumentation has the appropriate sensitivity and procedures are adequate to provide reliable data.

(5) A detailed quality assurance and quality control plan for all aspects of decommissioning is provided. In addition to the basis for accepting or rejecting data, a procedure for sampling additional grids when a verification Ra-226 sample fails to meet the standard is provided.

(6) Final verification (status survey) procedures are adequate to demonstrate compliance with the soil and structure cleanup standards. Survey instruments are specified and will be properly calibrated and tested. The proposed verification soil sampling density takes into consideration detection limits of sample analyses, the extent of expected contamination (unaffected area would have fewer measurements than affected areas), and limits to the gamma survey for the potentially contaminated area to be sampled. The gamma guideline value to be used for verification has been appropriately chosen. Also, there is a commitment to provide the verification soil Ra-226-gamma correlation and the number of grids that had additional removal because of excessive Ra-226 values, to confirm that the gamma guideline value was adequate. The plan provides adequate data collection beyond the expected excavation boundary (buffer zone).

    For structures to remain on site, adequate plans/procedures to demonstrate compliance with the limits for the surface activity dose in Appendix H of this SRP have been developed.

(7) The plan indicates the location of records important to decommissioning, discusses protection of health and safety, and demonstrates that decommissioning will be completed as soon as practicable.

(8) The decommissioning cost estimate is itemized in sufficient detail and a basis (source) for each cost is provided. The total cost is reasonable for the area of the site and the expected decommissioning activities.

5.2.4 Evaluation Findings

If the staff review, as described in this section, results in the acceptance of the processing site (soil and structures) decommissioning plan, the following conclusions may be presented in the TER:

> The staff has completed its review of the processing site decommissioning plan for soil and structures at the __________________ uranium mill facility. This review included an evaluation using the review procedures in Section 5.2.2, and the acceptance criteria outlined in Section 5.2.3 of this SRP.
>
> The licensee has provided an acceptable site decommissioning plan, including (1) appropriately substantiated site characterization data or plans in order to identify contaminated areas; (2) plans to clean up and place within the disposal cell all materials that are in excess of the standards and approved guidelines; (3) sufficient information concerning instrumentation and procedures; (4) plans for post-reclamation survey and sampling for verification that the soil and structures meet radiological limits; (5) location

for retention of records important to decommissioning; (6) methods to protect workers, the public, and the environment; and (7) cost estimate for the proposed decommissioning activities.

On the basis of the information presented in the RP and the detailed review conducted of proposed decommissioning activities for the _____________ uranium mill facility, the staff concludes that the information is acceptable and is in compliance with 10 CFR Part 40, Appendix A, Criterion 6(6), which requires that any portion of a licensed and/or disposal site not design to control radon releases, contain a concentration of radium in land, averaged over areas of 100 square meters, which, as a result of byproduct material does not exceed the background levels by more than: (i) 5 pCi/g of Ra-226 averaged over the first 15 cm (6 inches) below the surface, and (ii) 15 pCi/g of Ra-226 averaged over 15-cm-thick layers more than 15 cm below the surface. Also, the cleanup of other residual radionuclides in soil and residual surface activity on structures to remain on site meet the criteria developed with the radium benchmark dose approach, including a demonstration of ALARA and application of the unity test where applicable. For cases in which the licensee has proposed an alternative to the requirements of Criterion 6(6) or the approved guidance, the staff determines that the resulting level of protection is equivalent to that required in by this criterion.

The decommissioning plan mentions the location of records of information important to the decommissioning as required by 10 CFR 40.36(f) and meets the criteria of §40.42(g)(4) and (5). The plan sufficiently demonstrates that the proposed decommissioning activities will result in compliance with §40.42(j)(2) requirements to conduct a radiation survey (but do not have to meet Part 20 Subpart E criteria). The plan addresses the §40.42(k)(1) and (2) requirements that source material be properly disposed of and reasonable effort be made to eliminate residual radioactive contamination. The decommissioning cost estimate meets the requirements of §40.42(g)(4)(v) and Appendix A, Criterion 9.

5.2.5 References

American National Standards Institute (ANSI) Standards:

N42.17A-1989, “Performance Specifications for Health Physics Instrumentation-Portable Instrumentation for Use in Normal Environmental Conditions.”

N42.12-1994, “American National Standard Calibration and Usage of Thallium-Activated Sodium Iodide Detector Systems for Assay of Radionuclides.”

American Society for Testing and Materials (ASTM) Standards:

C 998-90 (reaffirmed 1995), “Standard Practice for Sampling Surface Soil for Radionuclides.”

D 5283-92, “Standard Practice for Generation of Environmental Data Related to Waste Management Activities: Quality Assurance and Quality Control Planning and Implementation.”

E 181-93, “Standard Test Methods for Detector Calibration and Analysis of Radionuclides.”

E 1893-97, “Standard Guide for Selection and Use of Portable Survey Instruments for Performing In Situ Radiological Assessments in Support of Decommissioning.”

National Council on Radiation Protection and Measurements. 1991. Report No. 112, “Calibration of Survey Instruments Used in Radiation Protection for the Assessment of Ionizing Radiation Fields and Radioactive Surface Contamination.”

Nuclear Regulatory Commission. 1983. "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, and Special Nuclear Material." Policy and Guidance Directive FC 83-23. Washington, D.C.

Nuclear Regulatory Commission. 1989. “Standard Format and Content of Decommissioning Plans Under 10 CFR Parts 30, 40, and 70.” Regulatory Guide 3.65. Washington D.C.

Nuclear Regulatory Commission. 1994. “Background as a Residual Radioactivity Criterion for Decommissioning.” Draft Report NUREG-1501. Washington D.C.

Nuclear Regulatory Commission. 1997a. “Uranium Mill Decommissioning Inspection.” NRC Inspection Manual, Inspection Procedure 87654. Washington D.C.

Nuclear Regulatory Commission. 1997b. "Multi-Agency Radiation Survey and Site Investigation Manual," NUREG-1575. Washington D.C.

Nuclear Regulatory Commission. 1998a. “A Nonparametric Statistical Methodology for the Design and Analysis of Final Status Decommissioning Surveys.” NUREG-1505, Rev. 1. Washington D.C.

Nuclear Regulatory Commission. 1998b. “Minimum Detectable Concentrations With Typical Radiation Survey Instruments for Various Contaminants and Field Conditions.” NUREG-1507. Washington D.C.

Nuclear Regulatory Commission. 1998c. “Demonstrating Compliance With the Radiological Criteria for License Termination.” Draft Regulatory Guide DG-4006. Washington D.C.

5.3 RADIATION SAFETY CONTROLS AND MONITORING

5.3.1 Areas of Review

The areas of review for radiation safety for protecting the site worker, the public, and the environment during reclamation and decommissioning are the control of releases, the radiation exposure and environmental monitoring programs, and the contamination control program. These activities at mill sites will involve occupational, and possibly public, exposures to radioactive materials that may require different or additional monitoring and control procedures than during site operation. Potential sources of exposure caused by working with tailings material are caused by airborne particulate contamination, radon gas, and external gamma radiation. Surface activity on equipment and structures to be dismantled or decontaminated could also be a source of exposure.

The reclamation and decommissioning plans should contain the licensee’s evaluation of the site’s current (operational or stand-by) radiation safety/protection plan or program and any proposed changes to the program for reclamation and decommissioning operations. The proposed measures should keep exposures ALARA and in compliance with the requirements of Part 20. Key components of the program should address hazards unique to the reclamation or decommissioning work environment. Any new activities that could increase hazards to general health and safety (e.g., cleanup in confined spaces, or removal of hazardous or flammable chemicals) should be identified, considering the NRC Memorandum of Understanding with the Occupational Safety and Health Administration.

5.3.2 Review Procedures

Determine that the proposed safety controls and all monitoring programs and procedures are sufficient to comply with the regulatory requirements during decommissioning and reclamation. A licensee will already have an approved radiation safety program in place; therefore, the focus of the review should be to ensure that the RP addresses those aspects of worker and public protection that require special consideration in planning reclamation and decommissioning activities. The environmental impacts of these activities will be addressed in the environmental assessment but any concerns requiring mitigation should be addressed in the RP. The RP should confirm the applicability of the radiation protection and monitoring programs to reclamation and decommissioning activities or should propose changes to address new program needs based upon review of the following

(1) Control of Releases

Determine whether the proposed systems and procedures (e.g., tailings stabilization, dust control) are sufficient to minimize environmental emissions from the tailings impoundment construction activities or structure demolition, taking into consideration important release mechanisms such as wind resuspension and surface erosion. Radon gas emanating from the tailings pile is also a radiation safety concern for workers and downwind offsite populations. However, because control of the source is not possible during tailings recontouring or cleanup, the reviewer should examine the means employed to limit the worker inhalation hazard (i.e., limiting exposure time, or using dust masks or respirators if required) and to establish an acceptable environmental monitoring program for measuring offsite airborne concentrations. Also, liquid releases can be created by rainwater runoff. Therefore, the review of the RP should include an evaluation, taking all exposure pathways into account, of proposals for ensuring offsite exposures are ALARA.

(2) External Radiation Exposure Monitoring Program

Determine if changes to the existing program are needed or if proposed changes are adequate. The reviewer should consider the types of surveys conducted, criteria for determining survey locations, frequency of surveys, action levels, management audits, and corrective action requirements. Also, consider if changes are required in the program for personal/personnel monitoring (film or TLD badges), including the criteria for placing workers in the program.

(3) Airborne Radiation Monitoring Program for Work Areas

Evaluate whether the proposed sampling locations, frequencies, procedures, and equipment are adequate to determine concentrations of airborne radioactive materials (including radon) in work areas during construction, demolition, and cleanup activities. Action levels, audits, and corrective action requirements should also be evaluated.

(4) Bioassay Program

Review the existing bioassay program or proposed changes to determine whether the proposed bioassay program is sufficient to protect employees performing decommissioning activities in yellowcake process areas.

(5) Contamination Control Program

Evaluate the occupational radiation survey program. This review should include proposed housekeeping and cleanup requirements and specifications for clean areas to control contamination. Action levels for clean areas and for the release of materials, equipment, and work clothes from clean areas and/or the site should be evaluated.

(6) Environmental Monitoring Program

Determine whether the environmental monitoring program proposed for measuring concentrations and quantities of both radioactive and non-radioactive materials released to and in the environs of the proposed facility, are sufficient to protect employees and the public. Potential releases during disposal cell construction and cleanup activities will be primarily from resuspended tailings material and radon gas. The reviewer should focus on the frequency of sampling and analysis, the types and sensitivity of analyses, action levels, corrective action requirements, and the required number of effluent and environmental monitoring stations (including criteria for determining monitor station locations considering the reclamation work to be done). The guidance in Regulatory Guide 4.20 (NRC, 1996) should be considered.

(7) Recordkeeping

Determine that the recordkeeping requirements for the radiation protection program has been addressed; that is, records of the provisions of the program and audits or other reviews of content and implementation are maintained for at least three years. Other records are maintained according to Subpart L of Part 20.

5.3.3 Acceptance Criteria

The radiation safety controls and monitoring for site worker, public, and environmental protection during reclamation and decommissioning will be acceptable if they meet the following criteria:

(1) The RP identifies the radiation safety concerns that are unique to reclamation and decommissioning activities. These concerns include characterization of radiation hazards associated with inhalation of resuspended tailings material or yellowcake, gamma exposure from working close to tailings, and inhalation of radon gas and its progeny (decay products) emanating from tailings material.

(2) The RP describes any changes to an existing radiation safety or monitoring program that would be necessary to ensure worker or public safety during reclamation or decommissioning activities.

(3) Regular wetting and/or phased stabilization efforts are used for control of windblown tailings material or yellowcake dust.

(4) The existing or proposed bioassay program for workers conforms to the applicable parts of Regulatory Guide 8.22, "Bioassay at Uranium Mills" (NRC, 1988) and Regulatory Guide 8.9, Revision 1, "Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program" (NRC, 1993), or an acceptable justification is provided for selecting an alternative approach.

(5) The existing or proposed workplace airborne radiological monitoring program is consistent with applicable parts of Regulatory Guide 8.25, "Air Sampling in the Workplace" (NRC, 1992) and Regulatory Guide 8.30, “Health Physics Surveys in Uranium Mills” (NRC, 1983), or an acceptable justification is provided for selecting an alternat approach. The monitoring program is sufficient to provide adequate protection of workers from radon gas exposures to maintain compliance with the inhalation limits in Part 20. If sampling locations will be revised, the RP contains one or more maps of the site that indicate the location of samplers for airborne radiation and provides the criteria for determining the revised locations.

(6) The existing or proposed contamination control program is consistent with the guidance on conducting surveys for contamination of skin and of personal clothing presented in Regulatory Guide 8.30 (NRC, 1983).

(7) The existing or proposed environmental radiological monitoring program is consistent with applicable parts of Regulatory Guide 4.14, "Radiological Effluent and Environmental Monitoring at Uranium Mills" (NRC, 1980), or an acceptable justification is provided for selecting an alternative approach. The licensee has adequately considered site-specific aspects of climate and topography in determining locations of offsite airborne monitoring stations and environmental sampling areas so that detection of maximum offsite concentrations of windblown tailings material and contamination from any other significant transport pathways applicable to the site is ensued.

(8) The proposed radiation protection program contains plans for documentation of exposures to all monitored workers and contractors and for availability of exposure records in a single location for inspection. The program provides for record-keeping that meets the requirements of 10 CFR 20.2102; at least annual review of the program content and implementation; and implementation of the ALARA requirements of 20.1101(d).

5.3.4 Evaluation Findings

If the staff's review, as described in this section, results in the acceptance of the radiation safety controls and monitoring for site worker and public protection during disposal cell construction and site cleanup, the following conclusions may be presented in the TER:

> The staff has completed its review of the radiation safety controls and monitoring for site worker, public, and environmental protection during reclamation and decommissioning at the _____________ uranium mill facility. This review included an evaluation using the review procedures in Section 5.3.2 and the acceptance criteria outlined in Section 5.3.3 of the Title II SRP.
>
> The licensee has provided an acceptable evaluation of radiation safety controls and monitoring required for worker, public, and environmental protection during reclamation and decommissioning activities, including (1) identification of the radiation safety concerns that are unique to reclamation construction and site cleanup activities; (2) any necessary changes and associated justifications in the radiation safety program, such as personnel and environmental monitoring; (3) identification and discussion of any changes in an existing radiation protection program that would require a license amendment; (4) control of potential contamination from windblown tailings by regular wetting and/or phased stabilization; and (5) the monitoring and contamination control programs will allow compliance with applicable portions of Parts 20 and 40.
>
> On the basis of the information presented in the RP and the detailed review conducted of the radiation safety controls and monitoring for worker, public, and environment protection during reclamation and decommissioning for the _____________ uranium mill facility, the NRC staff concludes that the information is acceptable and is in compliance with 10 CFR 20.1101, which requires development, documentation, and implementation of a radiation protection program ensuring compliance with Part 20 requirements and the use of procedures and engineering controls to achieve occupational and public doses that are ALARA. The Part 40, Appendix A, Criterion 8 requirements for implementation of control measures to limit dust emissions from tailings that are not

covered by standing liquids, to include wetting or chemical stabilization, will be met. [This requirement may be relaxed for tailings impoundments that have surfaces that are sheltered from wind exposure (i.e., below grade) or that have an interim cover.] The requirements in §40.42(g)(4)(iii) to describe methods that ensure protection of workers and the environment against radiation hazards during decommissioning have been met.

5.3.5 References

American National Standards Institute:

N13.11-1993, “Personnel Dosimetry Performance Criteria Testing.”

ANSI/HPS (Health Physics Society) N13.22-1995, “Bioassay Programs for Uranium.”

N42.20-1995, “American National Standard Performance Criteria for Active Personnel Radiation Monitors.”

HPS(Health Physics Society), N13.30-1996, “Performance Criteria for Radiobioassay.”

American Society for Testing and Materials. 1987. E 1167-87 (Reapproved 1996), “Standard Guide for Radiation Protection Program for Decommissioning Operations.”

Nuclear Regulatory Commission. 1980. “Radiological Effluent and Environmental Monitoring at Uranium Mills.” Regulatory Guide 4.14, Revision 1. Washington, D.C.

Nuclear Regulatory Commission. 1982. “Instructions for Recording and Reporting Occupational Radiation Exposure Data.” Regulatory Guide 8.7, Revision 1. Washington, D.C.

Nuclear Regulatory Commission. 1983. “Health Physics Surveys in Uranium Mills.” Regulatory Guide 8.30 (Revision 1 due in 2000). Washington, D.C.

Nuclear Regulatory Commission. 1988. “Bioassay at Uranium Mills.” Regulatory Guide 8.22, Revision 1. Washington, D.C.

Nuclear Regulatory Commission. 1992. “Air Sampling in the Workplace.” Regulatory Guide 8.25, Revision 1. Washington, D.C.

Nuclear Regulatory Commission. 1993. "Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program. Regulatory Guide 8.9, Revision 1. Washington D.C.

Nuclear Regulatory Commission. 1996. “Constraint on Releases of Airborne Radioactive Materials to the Environment for Licensees Other Than Power Reactors.” Regulatory Guide 4.20. Washington, D.C.

APPENDIX A

GUIDANCE TO THE NRC STAFF FOR REVIEWING HISTORICAL ASPECTS OF SITE PERFORMANCE FOR LICENSE RENEWALS AND AMENDMENTS

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For license renewals and amendments, the historical record of site operations contains valuable information for evaluating the licensing actions. Following are specific areas in which a compliance history or record of site operations and changes should be presented for review:

- Amendments and changes to operating practices or procedures

- License violations identified during Nuclear Regulatory Commission or Agreement State site inspections

- Excursions and resultant cleanup histories or status

- Exceedences of any radiation exposure, contamination, or release limits

- Exceedences of any nonradiation contaminant exposure or release limits

- Changes to any site characterization information important to the evaluation of the reclamation plan, such as changes to site location and layout, uses of adjacent lands and waters, meteorology, seismology, the geologic or hydrologic setting, ecology, background radiological or nonradiological characteristics, and other environmental features

- Effects of site operations, as data on radiological and nonradiological effects, accidents, and the economic effects of operations

- Changes to factors that may cause reconsideration of alternatives to the proposed action

- Changes to the economic costs and benefits for the facility since the last application

If, after reviewing these historical aspects of site operations, the staff concludes that the site has been operated so as to protect health, safety, and the environment, and that no unreviewed safety-related concerns have been identified, only those changes proposed by the license renewal or amendment or application should be reviewed, using the appropriate sections of this Standard Review Plan. Aspects of the facility and its operations that have not changed since the last license renewal or amendment should not be reexamined.

APPENDIX B

GUIDANCE TO THE NRC STAFF
ON THE USE OF
STANDARD STATISTICAL HYPOTHESIS TESTING

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STANDARD STATISTICAL HYPOTHESIS TESTING

Hypothesis Testing

Statistical hypothesis testing methods used for (1) establishing background water quality; (2) establishing ground-water protection standards for compliance monitoring; (3) determining the extent of ground-water contamination; and (4) establishing the ground-water cleanup goals, are described in this appendix.

The following discussion on the use of standard statistical hypothesis testing is adapted from U.S. Environmental Protection Agency (EPA) guidance (1989a, 1989b, 1993) and statistics texts (Haan, 1977; Gibbons, 1994; Abramson et al. 1988). The information presented here is referenced in other chapters of this Standard Review Plan (SRP). Statistical hypothesis testing methods are used for (1) establishing background water quality; (2) establishing ground-water protection standards for compliance monitoring; (3) determining the extent of ground-water contamination; and (4) establishing cleanup standards.

A statistical test of a hypothesis is a rule used for deciding whether a statement (i.e., null hypothesis) should be rejected in favor of an alternative statement (i.e., alternate hypothesis). The null hypothesis can be expressed as "There is no difference between background and onsite water quality." The alternate hypothesis can be expressed as "Onsite contaminant concentrations are above background." Because the concern lies only with concentrations of contaminants that are above background, this expression of the alternate hypothesis implies a one-tailed test of significance. Presumably, concentrations of any constituent in concentrations below background water quality pose no excess risk.

Two types of error are possible in hypothesis testing: the null hypothesis may be rejected when it is true (Type I error or false positive) or it may be accepted when it is false (Type II error or false negative). An example of Type I error in the context of this discussion would be to conclude that ground water has been contaminated from mill tailings when, in fact, it has not. Thus, Type I error could result in unnecessary remediation. Conversely, Type II error could result in contaminated water being left untreated. In customary notations, a (alpha) denotes the probability of the hypothesis test leading to a Type I error, and ß (beta) denotes the probability of a Type II error. Most statistical comparisons refer to the value 100a (in percent) as the level of significance. For example, if a = 0.01, there is a 1-percent chance of concluding that concentrations of contaminants are higher than background when they actually are not.

Before any ground-water monitoring criteria are determined, the implications of each type of error are considered. Clearly, if a Type I error is made, the error tends to favor protection of human health and the environment, but will result in unnecessary expenditure of capital. Thus, a higher value of a is more conservative when considering risk to human health and the environment; however, values that are too high could result in unrealistic restoration goals with little or no reduction in risk.

In testing hypotheses, the value for a is usually specified *a priori*. The value of ß, however, is not known unless the true parameter values being tested (e.g., the true background contaminant levels) are already known; this, of course, is rarely the case, as the parameter values are only estimated on the basis of a limited number of samples. In general, as the value of a decreases, the value of ß increases. The value of ß can also be reduced by ensuring that an adequate number of samples are obtained. Because an accurate assessment of background water quality is crucial to all subsequent monitoring efforts, the number of background samples collected should be sufficient to accept or reject the null hypothesis with a specified a.

Generally, the likelihood of Type II error can be sufficiently limited with a sample size that includes a minimum of six randomly distributed monitor well locations to capture spatial variations, and four sample periods to capture temporal variations. The Nuclear Regulatory Commission finds it acceptable to space samplings at least 2 weeks apart to capture temporal variations. Licensees are expected to take samples at longer intervals if seasonal variations are expected to be significant. The term "sample" is used to refer to the set of concentration measurements for each sampled constituent.

Thus, a single sample will contain at least 24 concentration measurements for each water quality parameter (constituent) of concern.

Ideally, background water quality is determined at a uranium mill site before the commencement of any milling operations. Background samples are collected both on site and off site. In the event that a mill site may have conducted operations before the determination of background water quality, then background water quality may have to be determined using only offsite, upgradient samples. Once the background sample has been collected, some statistical analysis is required. The statistical analysis process can be divided into five major steps, and these steps are common to any data that are being analyzed. These steps will be referred to extensively in later sections. They are the following:

(1) Checking for the validity of statistical assumptions
(2) Handling nondetects
(3) Analysis of variance (ANOVA) test
(4) Analysis for statistical intervals
(5) Strategies for multiple comparisons

From the regulatory viewpoint, EPA recommends (EPA,1993) that a specific statistical analysis should be performed to meet the ground-water protection standards. The following table, Table B.1. summarizes the use of statistical methods.

Table B.1. Summary of Statistical Methods

Compound	Type of Comparison	Recommended Method
Any compound in background	Background versus compliance well	ANOVA Tolerance limits Prediction intervals
	Intra-well	Control charts
ACL/MCL specific*	Fixed standard	Confidence intervals Tolerance limits
Synthetic	Many nondetects in data set	Cohen's adjustment Aitchison's adjustment

*ACL=alternate concentration limit; MCL =maximum concentration limit.

Checking for the Validity of Statistical Assumptions

The inherent assumption with all parametric statistical methods described in Table B.1 is that the data being analyzed are normally distributed or can be transformed into a normal distribution. This assumption should be verified by testing the normality of data. If the measured data are not normally distributed, the log of measured data should be tested for lognormal distribution. In environmental compliance, measured concentration data will be most likely to be lognormally distributed. If the background sample exhibits variability in constituent concentrations over several orders of magnitude and a high positive skew, then log-transformation of the sample data may be necessary to obtain a distribution that more closely approximates normal. If the background sample exhibits a bimodal distribution due to zones of distinct water quality, it may be necessary to split the sample to obtain two normally distributed samples—one for each zone of water quality. When a sample is split, it may be necessary to obtain additional measurements from new sample locations, to obtain the minimum of six measurements for each distinct water quality zone. If bimodal distributions are encountered because of temporal variations, it is acceptable to evaluate the measurements collected during each sample period separately; this would result in four background samples, each containing a minimum of six measurements for each constituent. Whenever a bimodal distribution is encountered, the reviewer shall verify that it is caused by changes in natural variations in water quality, and not caused by the presence of contamination.

Summary statistics are calculated for the background sample. The two most important statistics for hypothesis testing are the mean and the standard deviation. For normal distributions, the mean represents the arithmetic mean; for lognormal distributions, the mean represents the geometric mean of the sample data. The following methods can be used for testing the normality or lognormality of data: probability plots, coefficient of skewness, Shapiro-Wilk test, Shapiro-Francia test, and probability plot correlation coefficient (EPA, 1993). If the assumption of lognormality is valid, further statistical analyses should be performed. However, if the data are neither normal nor lognormal, a non-parametric technique should be used.

Handling Nondetects

If fewer than 15 percent of all samples are nondetects, replace each nondetect by half its detection or quantization limit. Care should be taken in choosing between the method detection limit (MDL) and the physical quantitation limit (PQL) (EPA, 1993). The nondetects are reported as "undetected" or "detected but not quantified" and with or without an estimated concentration. If an estimated concentration value is given, the value should be used for statistical analysis. Otherwise, nondetects should be substituted by one-half of PQL since PQL is a better representative of actual laboratory conditions than MDL. After this correction, the data can be analyzed by any parametric approach, (e.g., ANOVA or statistical interval).

If more than 15 percent but fewer than 50 percent of all samples are nondetects, either Cohen's adjustment or Aitchison's (EPA, 1993) adjustment should be applied (also see Helsel, 1990). If more than 50 percent but fewer than 90 percent of the samples are nondetects, nonparametric statistical intervals, for example, Poisson Prediction Limit (EPA, 1993), should be used.

Analysis of Variance (ANOVA) Test

The ANOVA test is used to compare concentration data from several compliance wells with concentration data with background wells. This method is used to test for the statistically significant evidence of higher mean concentration in compliance wells than the background concentration as provided by background wells. ANOVA is best used for comparisons between wells that are hydraulically upgradient of a site and those that are downgradient from the site. The parametric ANOVA technique makes two key assumptions: (1) that the data residual are normally distributed and (2) that the group variances are approximately equal. If any of these assumptions are not valid, it is recommended that a nonparametric approach, such as the Kruskal-Wallis test or the Wilcoxon Rank-Sum test (also known as the Mann-Whitney U test) (EPA, 1993), is used in analyzing the data. The Kruskal-Wallis test is used when three or more well groups are compared; however, for comparing one compliance well with one background well, the Wilcoxon Rank-Sum test should be used. A non-parametric ANOVA based on ranks, followed by multiple comparison procedures can be used to identify statistically significant evidence of contamination. The method includes estimation and testing of the contrasts between each compliance well median and the background median levels for each constituent.

Analysis for Statistical Intervals

There are three types of statistical intervals that are most commonly constructed from the data: confidence intervals, tolerance intervals, and prediction intervals. The interpretation and use of each of these intervals is quite distinct. A confidence interval is a random interval that is designed to contain the specified population parameter with a designated level of confidence or probability, denoted as 1!a. A confidence interval should be used only in two situations for ground-water data analysis:
(1) when directly specified by permit or (2) in compliance monitoring, when downgradient samples are being compared with a fixed ground-water protection standard, (e.g., Part 40 or ACLs). In other cases, it is usually desirable to use either tolerance or prediction intervals.

A tolerance interval, also a random interval, is designed to contain a designated proportion of population with a certain confidence level. Two coefficients are associated with any tolerance interval: coverage and tolerance coefficients. Coverage is the proportion of the population that the interval is supposed to contain and the tolerance coefficient is the degree of confidence with which the interval reaches the specified coverage. A tolerance interval with coverage of 99 percent and a tolerance coefficient of 99 percent are constructed to contain, on average, 99 percent of the distribution with a probability of 99 percent. Since a tolerance interval is designed to cover all but a small percentage of the population's measurements, observations should rarely exceed the upper tolerance limit when testing small sample size. The tolerance intervals can be used in detection monitoring when comparing compliance data with background values. They can be used in compliance monitoring when comparing compliance data with certain fixed standards, (e.g., Part 40 or ACLs).

A one-sided test of significance is used to determine the upper limit of the range of background concentrations. This is also known as the tolerance limit method. This limit is given by

$$U = \bar{x} + t_{?,?} s_x \tag{1.1}$$

where $\bar{x}$ is the mean value determined for the background sample; s_x is the standard deviation of the background sample; $t_{?,?}$ is the *t*-statistic for $? = (1 - a)$; and $? = (n - 1)$ of degrees of freedom, where *n* is the number of background measurements for each constituent. Values for *t*-statistics are obtained from *t*-tables that can be found in most basic statistics textbooks. The value of *U* for each constituent is interpreted as the maximum concentration of that constituent that may be present in any single monitor well without concluding that the constituent concentration is above the range of reasonable background concentrations.

Equation (1.1) is used for determining whether constituent concentrations meet the background criterion in any single well. However, it is often the case that a licensee wishes to demonstrate compliance with the background criterion by using well field average concentrations for each constituent. That is, while a concentration in one or more wells may exceed background, the water quality of the aquifer, on average, meets the background criterion. NRC finds this approach to be acceptable; however, it necessitates a change to Eq. (4.1). Rather than the standard deviation of the single background sample (s_x), the standard deviation of the sample average (s_x) must be used.

Normally, this would require that at least six background samples be collected, the mean of each sample be determined, and a calculation be made of the standard deviation for these background sample means. However, it is rarely the case that enough background samples are collected to calculate $s_{\bar{x}}$ directly. For these purposes, $s_{\bar{x}}$ can be approximated by the equation

$$s_{\bar{x}} = \frac{s_x}{\sqrt{n}} \tag{1.2}$$

A prediction interval is a statistical interval calculated to include one or more future observations from the same population with a specified confidence. In ground-water monitoring, a prediction interval approach can be used in two ways: (1) to compare compliance well data with background well data and (2) to make intrawell comparisons for an uncontaminated well.   If future observations are found to be in the prediction interval, then there is no contamination. However, if the measured concentration is above the prediction interval's upper limit, it is statistically significant evidence of contamination.

Another commonly used technique for intrawell comparison is control charts (EPA, 1993). The control chart method is recommended for uncontaminated wells only. This is an effective technique to monitor contamination over time. The control charts should be constructed with data that are free from seasonal variability. It is important to note that the control charts should not be used for wells that show evidence of contamination or an increasing trend.

Strategies for Multiple Comparisons

When more than one statistical test is performed during any monitoring period, the problem of multiple comparisons needs to be addressed. These comparisons can arise from the fact that multiple compliance wells were tested against multiple background wells for several contaminants. Usually the same statistical test is performed in every comparison, each test having a fixed level of confidence (1 ! a), and a corresponding false positive rate, a.

The selection of an a value is not arbitrary: the consequences that would result from a Type I error must be considered. In most cases, a Type I error favors protection of human health and the environment, but results in unnecessary expenditure of capital for restoration. Thus, a higher value of a is more conservative when considering risk to human health and the environment; however, values that are too high could result in unrealistic cleanup standards, with little or no reduction in risk. EPA recommends an a-value of 0.05 (EPA, 1989a). The number of contaminants present at a site should also be considered when selecting a value for a. For example, the EPA-recommended a-value of 0.05 translates to a 1-in-20 chance of a Type I error. However, if 20 constituents are being evaluated for cleanup standards, and each has a 1-in-20 chance of Type I error, the result is a 64 percent chance that at least one Type I error will occur. In such cases, using an a-value of 0.05 is likely to result in unnecessary restoration. However, a-values lower than 0.01 should not be used at sites where public water supplies or sensitive environmental areas may be threatened by contamination.

Once a background sample has been properly collected and analyzed for each constituent of concern, it is then possible to conduct hypothesis testing for establishing cleanup standards and ground-water protection standards, and for determining the extent of any existing contamination. The review should confirm that the statistical method used complies with the following, as appropriate:

(1) The statistical method used to evaluate ground-water monitoring data is appropriate for the distribution of chemical parameters or hazardous constituents. If the distribution of the chemical parameters or hazardous constituents is shown by the owner or operator to be inappropriate for a normal theory test, then the data are transformed or a distribution-free theory test is used. If the distributions for the constituents differ, more than one statistical method is needed.

(2) If an individual well comparison procedure is used to compare an individual compliance well constituent concentration with background constituent concentrations or a ground-water protection standard, the test is done at a Type I error level no less than 0.01 for each testing period. If a multiple comparisons procedure is used, the Type I error rate for each testing period is no less than 0.05; however, the Type I error of no less than 0.01 for individual well comparisons is maintained. This does not apply to tolerance intervals, prediction intervals, or control charts.

(3) If a control chart approach is used to evaluate ground-water monitoring data, the specific type of control chart and its associated parameter values are proposed by the licensee.

(4) If a tolerance interval or a prediction interval is used to evaluate ground-water monitoring data, the levels of confidence and, for tolerance intervals, the percentage of the population that the interval must contain, are proposed by the licensee. These parameters are determined after

considering the number of samples in the background database, the data distribution, and the range of the concentration values for each constituent of concern.

(5) The statistical method accounts for data below the limit of detection with one or more statistical procedures that are protective of human health and the environment. The limit of detection that is used in the statistical method is the lowest concentration level that can be reliably achieved, within specified limits of precision and accuracy, during routine laboratory operating conditions that are available to the facility.

(6) If necessary, the statistical method includes procedures to control or correct for seasonal and spatial variability as well as temporal correlation in the data.

References

Abramson, L.R., et al. 1988. “Statistical Methods for Nuclear Material Management”. NUREG/CR-4604. Washington, D.C.: U.S. Nuclear Regulatory Commission

Gibbons, R.D. 1994, *Statistical Methods for Ground-water Monitoring.*New York: John Wiley & Sons, Inc.

Maan, C.T. 1977. *Statistical Methods in Hydrology*. Ames, Iowa. Iowa State University Press

Helsel, D.R. 1990. “Less Than Obvious Statistical Treatment of Data Below the Detection Limit,” *Environmental Science and Technology*. 24, 12, pp. 1766, 1774.

Environmental Protection Agency. 1989a. *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Final Guidance.* EPA/530/SW-89/026.

Environmental Protection Agency, 1989b. “Risk Assessment Guidance for Superfund,” Vol. I, *Human Health Evaluation Manual (Interim Final 9/29/89).* OSWER Directive 9285.7-01a.

Environmental Protection Agency. 1993. *Statistical Training Course for Ground-water Monitoring Data Analysis.* EPA/530-R-93-003.

APPENDIX C

OUTLINE RECOMMENDED BY THE NRC STAFF FOR PREPARING SITE-SPECIFIC FACILITY RECLAMATION AND STABILIZATION COST ESTIMATES FOR REVIEW

APPENDIX C
OUTLINE RECOMMENDED BY THE NRC STAFF FOR PREPARING SITE-SPECIFIC FACILITY RECLAMATION AND STABILIZATION COST ESTIMATES FOR REVIEW

As required by Criteria 9 and 10 of 10 CFR Part 40, Appendix A, the licensee shall supply sufficient information for the Nuclear Regulatory Commission to verify that the amount of coverage provided by the financial assurance accounts for all necessary activities required under the license to allow the license to be terminated. Cost estimates for the following items (where applicable) should be submitted to NRC with the initial license application or reclamation plan, and should be updated annually as specified in the license: unit costs, calculations, references, assumptions, and equipment and operator efficiencies. Cost estimates must be calculated on the basis of completion of all activities by a third party.

The detailed cost information necessary to verify the cost estimates for the preceding categories of closure work is described in the recommended outline that follows.

(I) Facility Decommissioning

This includes dismantling, decontamination, and disposal of all structures and equipment. This work may be done in two phases. In the first phase, only the equipment not used for ground-water restoration (including the stability monitoring period) is removed. Well plugging and removal of the remaining equipment would be performed in a second phase, after the approved completion of ground-water restoration. The buildings may be decontaminated and released for unrestricted use.

(A) Salvageable building and equipment decontamination. For each building or piece of equipment listed, the following data should be provided:

(1) Labor for dismantling and decontamination

(a) Man-hours and categories of labor

(b) Average hourly wage for each category

(c) Total labor cost (benefits, insurance, etc., and all labor overhead must be included here or calculated on the basis of total project labor)

(2) Equipment and material for dismantling and decontamination

(a) Itemization of equipment and material to be used for decontamination

(b) Itemized cost for material and equipment cost per hour listed in (a) above (equipment costs must include hourly operating, ownership, and overhead expenses)

(c) Operating hours for each piece of equipment

(d) Total cost of equipment and material

(B) Nonsalvageable building and equipment disposal:

(1) List of major categories of building and equipment to be disposed of and their corresponding quantities:

(a) Structures (list each major), metric tons [tons(short)] of material, and building volume cubic meters (cubic yards)

(b) Foundation concrete [cubic meters (cubic yards)]

(c) Process equipment [metric tons (tons (short)]

(d) Piping and insulation (lump sum)

(e) Electrical and instrumentation (lump sum)

(2) Unit cost of disposal for each item above (include equipment, labor, material, transportation, and disposal costs)

(3) List each chemical solution within the mill area and state how it will be disposed of along with the associated cost of disposal

(4) Total cost

(C) Restoration of contaminated areas (ore storage pad, access roads, process area, affected ground water, evaporation pond residues, etc.)

Removal and disposal of 11(e)2 byproduct material—In Part 40, Appendix A, Criterion 2, it is required that these materials are to be transported and disposed of at a licensed tailings area or a licensed disposal site. The quantity of material to be removed, the distance to the disposal site, and the fees charged by the receiving facility are important considerations in determining the costs of disposal.

Reclamation—This entails recontouring the tailings disposal cell and evaporation ponds and placing top soil or other materials acceptable to NRC. Reclamation may also include revegetation.

(1) Removal:

(a) Area, depth, and quantity of material to be removed [area, meters (feet), and cubic meters (cubic yard)—or size of liner if appropriate]

(b) Unit cost (include excavation, loading, transportation, and deposition)

(c) Total cost (equipment and labor)

(2) Revegetation:

(a) Area to be revegetated (acre)

(b) Unit cost (include fill material replacing topsoil, and revegetation cost)

(c) Total cost (equipment, labor, and materials)

(II) Ground-water Restoration and Well Plugging

In most cases, ground-water restoration consists of ground water sweeping and water treatment, with partial reinjection. The capital costs are for water treatment equipment, costs of operation, maintenance, and replacement filters for the restoration phase.

(A) Method of restoration

(B) Volume of aquifer required to be restored, area and thickness of aquifer, number of required pumping cycles, and cycling time

(C) Equipment associated with aquifer restoration (e.g., reverse osmosis unit)

(D) Verification sample analysis:

(1) Number of samples

(2) Unit cost for sample collection and analysis (per sample)

(3) Total cost for verification sample analysis

(E) Well plugging:

(1) Number of drill holes to be plugged

(2) Depth and size of each drill hole

(3) Material to be used for plugging including acquisition, transportation, and plugging

(4) Total cost for well plugging

(F) Total cost for ground-water restoration.

(III) Radiological Survey and Environmental Monitoring

Radiological Survey—Surveys and soil samples for radium in areas to be released for restricted use. Soils around the tailings disposal cell, evaporation ponds, and process buildings should be analyzed for radium content. A gamma survey of all areas should be made before release for unrestricted use. All equipment released for unrestricted use should be surveyed and records maintained.

(A) Soil samples for radium

(B) Decommissioning equipment and building smear samples

(C) Gamma survey

(D) Environmental monitoring: Costs of labor, materials, and analysis for continuation of environmental monitoring program throughout reclamation

(E) Total cost:

(1) Number of each kind of sample listed above

(2) Unit cost for sample and analysis (price per sample)

(3) Total cost for radiological survey

(IV) Project Management Costs and Miscellaneous

Itemize estimated costs associated with project management, engineering changes. mobilization costs, legal expenses, power costs during reclamation, quality control, radiological safety costs, etc.

(V) Labor and Equipment Overhead, Contractor Profit

Overhead costs for labor and equipment and contractor profit may be calculated as separate items or loaded into hourly rates. If included in hourly rates, the unit costs must identify the percentages applied for each area.

(VI) Contingency

The licensee should include a contingency amount to the total cost estimate for the final site closure. The staff currently considers a 15 percent contingency to be an acceptable minimum amount.

(VIII) Adjustments to Surety Amounts

The licensee is required by Part 40, Appendix A, Criterion 9, to adjust cost estimates annually to account for inflation and changes in reclamation plans. The submittal should be in the form of a request for amendment to the license.

(A) Adjustments for inflation: The licensee should submit a revised surety incorporating adjustments to the cost estimates for inflation 90 days before each anniversary of the date on which the first reclamation plan and cost estimate was approved. The adjustment should be made using the inflation rule indicated by the change in the Urban Consumer Price Index published by the U.S. Department of Labor, Bureau of Labor Statistics.

(B) Changes in Plans:

(1) Changes in the process, such as size or method of operation

(2) Licensee-initiated changes in reclamation plans or reclamation/decommissioning activities performed

(3) Adjustments to reclamation plans required by NRC

(4) Proposed revisions to reclamation plans must be thoroughly documented and cost estimates and the basis for cost estimates must be detailed for NRC review and approval. Where a licensee is authorized by NRC to secure a surety arrangement with the State, no reduction to the surety amount shall be initiated without prior NRC approval. Copies of all correspondence relating to the surety between the licensee and the State shall be submitted to NRC. If authorized by NRC to maintain a surety with the State as the beneficiary, it is the responsibility of the licensee to give NRC with verification of that surety; ensure that the agreement with the State specifically identifies the financial surety's application, uranium mill tailings site, and decommissioning/reclamation requirements; and transfer the long-term surveillance and control fee to the U.S. Department of the Treasury before license termination.

All costs (unit and total) are to be estimated on the basis of independent contractor costs (include overhead and profit in unit costs or as 3 percent of total). Equipment owned by the licensee and the availability of licensee staff should not be considered in the estimate to reduce cost calculations. All costs should be based on current-year dollars. Credit for salvage value is generally not acceptable on the estimated costs.

The staff review may include a comparison of unit cost estimates with standard construction cost guides (e.g., Dodge Guide, Data Quest) and discussions with appropriate State or local authorities (highway cost construction). The licensee should provide supporting information or the basis for selection of the unit cost figures used in estimates.

APPENDIX D

GUIDANCE TO THE NRC STAFF FOR REVIEWING LONG-TERM SURVEILLANCE PLANS

APPENDIX D

GUIDANCE TO THE NRC STAFF FOR REVIEWING LONG-TERM SURVEILLANCE PLANS

1.0 BACKGROUND

The Atomic Energy Act of 1954, as amended (hereafter, the Act), contains, in part, to the statutory requirements for transfer of the title and custody of byproduct material and any land used for the disposal of such byproduct material from a uranium mill licensee to either Federal or State control, before termination of the licensee's specific license. These requirements are codified in 10 CFR Part 40, at Section 40.28, "General license for custody and long-term care of uranium or thorium byproduct materials disposal sites." Section 40.28, along with pertinent requirements stated in Appendix A to Part 40 (hereafter Appendix A), requires the completion of certain licensing actions before the transfer of the land and byproduct material to the United States or the appropriate State for long-term care. As part of the license termination process, the intended custodial agency, Federal or State government, will prepare a long-term surveillance plan (LTSP) for review and concurrence/acceptance by the Nuclear Regulatory Commission. The LTSP must document the general licensee's plan for long-term care, including inspection, monitoring, maintenance, and emergency measures necessary to protect public health and safety. This document presents guidance to the NRC staff on review of the LTSP. Standard Review Plan (SRP) Appendix E presents guidance on the license termination process, and presents the role of the LTSP in the overall context of the license termination process.

2.0 REVIEW OF LTSP

2.1 Areas of Review

In accordance with 10 CFR 40.28(b), the LTSP should present the following information:

! A legal description of the disposal site to be transferred and licensed;

! A detailed description of the final conditions of the disposal site, including existing ground-water characterization;

! A description of the long-term surveillance program, including proposed inspection frequency and reporting to the Commission; frequency and extent of ground-water monitoring, if required; appropriate constituent limits for ground-water; inspection personnel qualifications; inspection procedures; recordkeeping; and quality assurance procedures;

! The criteria for followup inspections in response to unusual observations from routine inspections or extreme natural events; and

! The criteria for instituting maintenance or emergency measures.

2.2 Information Reviewed

2.2.1 Legal Description and Ownership of the Land

The reviewer shall examine the documents to ensure that the ownership and legal description of the land are satisfactory. The land ownership review shall include review of (1) the legal description of the disposal site; (2) a brief narrative of the disposal area land ownership, including the number of acres involved and the type of real estate instruments associated with the acquisitions; (3) information associated with the land transaction [i.e., book, page, county, State, and date of deeds; and agreement number and date associated with Department of Energy (DOE)/tribe agreement (waiver of liability from tribe when land is part of a reservation or has trust status)]; and (4) a statement that real estate correspondence and instruments are maintained and filed by the property management branch of the pertinent custodial agency. The documentation should clearly establish the custodial agency's land ownership when the land transfer takes place.

2.2.2 Final Condition of the Disposal Site

The reviewer shall examine the following: (1) documentation of defined and characterized final closure site condition; (2) as-built drawings; (3) description of disposal cell design; (4) final topographic map; (5) vicinity map; (6) ground and aerial photographs; (6) survey monuments, site markers, and signs; and (7) existing ground-water characterization and protection activities (if necessary), ground-water monitoring well network and screening monitoring to detect changes in ground-water quality from tailings (including evaluating the monitoring data to quantify the rate and magnitude of change). Some of the information may be referenced to the information already submitted to NRC (such as the completion report), and the staff findings on the previously submitted information may be used in this review. It is noted that the final disposition of the tailings residual radioactive material, or wastes at the milling site, should be such that ongoing active maintenance is not necessary to preserve isolation. The description of the final disposal site condition and the suggested ground-water monitoring should be of sufficient detail so that future inspectors have a baseline to determine changes to the site.

2.2.3 Long-Term Surveillance Program

The staff shall review the surveillance (inspection and monitoring) program for

(1) Frequency of Inspection----The physical condition of the site (fence, site markers, drains/ditches, rock-mulch/vegetative cover, etc.) should be inspected annually to determine any need for maintenance or monitoring or both. In addition, an inspection should follow an unusual event, such as a heavy storm or an earthquake. On the basis of a site-specific evaluation, NRC may require more frequent site inspections because of the particular features of a disposal site.

(2) Reporting to the Commission----Results of the inspections for all the sites under the licensee's jurisdiction will be reported to NRC annually within 90 days of the last site inspection in that calendar year. Any site at which unusual damage or disruption is discovered during the inspection, however, requires a preliminary site inspection report to be submitted within 60 days.

(3) Ground-water Monitoring----The reviewer shall examine long-term surveillance plans to ensure that a ground-water monitoring program is in place to verify that the ground-water quality at the site will continue to meet applicable standards. The long-term surveillance plan will be acceptable if

(a) Background, point of compliance (POC), and, if applicable, point of exposure (POE) have been located as described in the existing license. Wells should be correctly placed as to surface locations and aquifer completions. Well locations should be surveyed in, and should be located on site maps drawn to scale.

(b) The same ground-water protection standards [point of ground-water protection standards or alternate concentration limits (ACLs)] as in the existing license continue to apply. If there has been no leakage from the impoundment into the ground-water, appropriate ground-water parameters should be monitored and detection concentrations established that will give early warning of leakage. Appropriate parameters should be indicative of the tailings material and not significantly affected by retardation reactions. For acid tailings, appropriate detection parameters might include total dissolved solids, chloride, or sulfate.

(c) The sampling frequency is sufficient to protect the public and environment at the POE and sufficient to ensure that the ground-water downgradient of the POC will not be degraded to any great extent before contamination is detected. This will require a knowledge of potential contaminant plume velocities. It is anticipated that the calculation of potential contaminant plume velocities will be based on advective calculations (ASTM Standards D 5447, D 5490, D 5609, D 5610, D 5611, D 5718, E 978, and Anderson and Woessner, 1992). However, more complex calculations that include such processes as dispersion and retardation may be performed if site conditions warrant them. For sites with ACLs, the sampling frequency should be sufficient to detect a potential contaminant plume, well before ground water at the POE is degraded.

It is anticipated for most sites that routine monitoring of once every 3 years will be acceptable unless site-specific conditions warrant an increased or decreased frequency of monitoring. If more frequent monitoring is required; the reviewer shall also need to identify the increase in the long-term care payment that must be made to support the more frequent monitoring. This increase will need to be included in the existing surety as well as the long-term care payment made at the time of license termination.

(d) Water quality sampling and analysis procedures use appropriate ASTM or equivalent standards. Wells should be constructed to prevent surface-water contamination and capped and secured to prevent tampering (ASTM Standard D 5787).

(e) Any potential needs for future well maintenance or replacement are identified. If periodic well replacement is projected, an increase in the long-term care payment must be included (ASTM Standard D5978).

(f) Actions that the long-term custodian would take should ground-water protection standards be exceeded are described.

If the staff's review results in acceptance of the LTSP, the staff may conclude that DOE will conduct an LTSP that will confirm that constituents of concern will remain below the relevant standards in Part 40, Appendix A, CriteriA 5B(5) and (6). The staff may also conclude that enough funds are available to cover the costs of long-term surveillance and control as required in Part 40, Appendix A, Criterion 10, and that site inspections are planned as required in Part 40, Appendix A, Criterion 12.

(4) Inspection Personnel Qualifications----The inspection team should be qualified to inspect such site features as subsidence and cracking; erosion by surface water; degradation of erosion protection (rock mulch cover or vegetative cover); integrity of site markers, fences, and

settlement plates; and monitoring to verify the presence and concentration limits of hazardous constituents in the ground water. For inspections that follow unusual events, the team should consist of technical personnel of appropriate disciplines.

(5) Inspection Procedures----The LTSP should present details of the inspection procedures, such as checklists of items to be inspected; measurement or observation to be made; procedure for documenting the inspection data (photo, video, aerial photo as needed); and duration of inspection (1 to 2 days).

(6) Recordkeeping and Quality Assurance Procedures----Inspection data should be retained in a format suitable for future retrieval on a long-term basis. The quality assurance aspect of the collection of site and ground-water data, interpretation of the collected data, report preparation, and long-term retention of data should be reviewed.

2.2.4 Followup Inspections

The criteria for followup inspections in response to unusual observations from routine inspections or extreme natural events should be reviewed.

(1) If any unusual observation from the inspection warrants a detailed evaluation, then an unscheduled inspection (followup inspection) should be conducted for a detailed evaluation of the unusual observation encountered in the earlier inspection. The plan should discuss the level of physical distress to the site (settlement/crack magnitude, extent of subsidence, extent of degradation of erosion protection, etc.) and limits of the constituents not to be exceeded in the ground-water that would warrant a further detailed evaluation of the problem to determine the need for a restoration activity.

(2) Occurrence of extreme natural events, such as storms and earthquakes, warrants an inspection to verify the physical condition/integrity of the disposal site. The plan should present the magnitude of the natural events that would trigger this inspection.

2.2.5 Criteria for Instituting Maintenance or Emergency Measures

The plan should also present the criteria or the event that will trigger the initiation of maintenance and other emergency measures to restore the integrity of the disposal site and to protect the health and safety of the public. Quantitative and, if not practical, qualitative criteria that would trigger these measures should be discussed in the LTSP.

3.0 CONCLUSIONS

On the basis of its review of the LTSP, the staff should be able to conclude that the LTSP is in compliance with (1) the content requirements in 10 CFR 40.28(b) for LTSPs; (2) the ownership of site and byproduct material requirement in Criterion 11 of Appendix A; and (3) the surveillance plan requirement in Criterion 12 of Appendix A. If the LTSP is in compliance with these requirements, the staff can accept the LTSP.

4.0 REFERENCES

Anderson, M.P., and W.W. Woessner. 1992. *Applied Ground-water Modeling: Simulation of Flow and Transport.* New York: Academic Press.

American Society for Testing and Materials (ASTM) Standards

D 5447, "Standard Guide for Application of a Ground-water Flow Model to a Site-Specific Problem."

D 5490, "Standard Guide for Comparing Ground-water Flow Model Simulations to Site-Specific Information."

D 5609, "Standard Guide for Defining Boundary Conditions in Ground-water Flow Modeling."

D 5610, "Standard Guide for Defining Initial Conditions in Ground-water Flow Modeling."

D 5611, "Standard Guide for Conducting a Sensitivity Analysis for a Ground-water Flow Model Application."

D 5718, "Standard Guide for Documenting Ground-water Flow Model Application."

D 5787, "Standard Practice for Monitoring Well Protection."

D 5978, "Standard Guide for Maintenance and Rehabilitation of Ground-water Monitoring Wells."

E 978, "Standard Practice for Evaluating Mathematical Models for the Environmental Fate of Chemicals."

Nuclear Regulatory Commission. 1980a. "Final Generic Environmental Impact Statement on Uranium Milling," NUREG-0706, 3 vols. Washington, D.C. September 1980.

Nuclear Regulatory Commission. 1980b. "OELD Legal Opinion on Two Questions Relating to Operation of the Uranium Mill Tailings Radiation Control Act of 1978." Memorandum from H.K. Shaper to Commissioner Ahearne, April 28, 1980.

Nuclear Regulatory Commission. 1990. "Rulemaking Issue (Affirmation): Amendments to 10 CFR Part 40 for General Licenses for the Custody and Long-Term Care of Uranium and Thorium Mill Tailings Disposal Sites." SECY-90-282. Washington, D.C. August 10, 1990.

APPENDIX E

GUIDANCE TO THE NRC STAFF ON THE LICENSE TERMINATION PROCESS FOR LICENSEES OF CONVENTIONAL URANIUM MILLS

APPENDIX E
GUIDANCE TO THE NRC STAFF ON THE LICENSE TERMINATION PROCESS FOR LICENSEES OF CONVENTIONAL URANIUM MILLS

CONTENTS

1.0 BACKGROUND

The Atomic Energy Act of 1954, as amended (AEA) contains the statutory requirements for the transfer of the title and custody to byproduct material and any land used for the disposal of such byproduct material from a uranium mill licensee to either Federal or State control, before termination of the licensee's specific license. These requirements are codified in 10 CFR Part 40, at Section 40.28, "General license for custody and long-term care of uranium or thorium byproduct materials disposal sites." Section 40.28, along with pertinent requirements stated in Appendix A to 10 CFR Part 40 (hereafter Appendix A), provides for the completion of certain licensing actions before the transfer of the land and byproduct material to the United States or the State where the disposal site is located for long-term care.

This document gives the U.S. Nuclear Regulatory Commission staff specific directions to be applied in the course of the license termination process for Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA) Title II sites. The license termination process, including the roles of the respective agencies and organizations involved in this process, is discussed in general. Various relevant issues are addressed in greater detail. This is the initial version of this guidance document, and as specific uranium mill licenses are terminated and title to the land and byproduct material is transferred to the appropriate government agency, future revisions are likely to be necessary. These revisions will address not only issues yet to be identified, but also will provide any additional necessary clarification of issues discussed herein.

2.0 ROLES OF INVOLVED ORGANIZATIONS

2.1 U.S. Nuclear Regulatory Commission

In accordance with Section 83c of the AEA for NRC licensees and Section 274c for Agreement State licensees, before termination of the specific license, NRC determines whether the licensee has met all applicable standards and requirements or whether a licensee-proposed alternative meets the standards. For NRC licensees, this will involve NRC review of licensee submittals, relative to the completion of decommissioning, reclamation, and, if necessary, ground-water cleanup. For Agreement State licensees, the State will conduct these reviews in accordance with its standards and regulations. In accordance with 10 CFR 40.28, NRC must concur with the State on the termination of its specific licenses. NRC's determination with respect to Section 274c of the AEA will be conducted by the Office of State Programs (OSP) in consultation with the Office of Nuclear Material Safety and Safeguards. It is anticipated that this determination will rely on OSP's reviews of the Agreement State's program and on the State's documentation of its conclusions concerning the licensee's performance of remedial actions.

In addition, the staff reviews the site long-term surveillance plan (LTSP) submitted by the custodial agency, for both NRC and Agreement State sites. On NRC acceptance of the LTSP, NRC terminates the specific license (or concurs in the Agreement State's termination) and places the long-term care and surveillance of the site by the custodial agency under the general license provided at 10 CFR 40.28.

A final NRC responsibility is the determination of the final amount of long-term site surveillance funding. Criterion 10 of Appendix A specifies a minimum charge of $250,000 (1978 dollars), revised to reflect inflation, which may be escalated on a site-specific basis because of surveillance and long-term monitoring controls beyond those specified in Criterion 12 of Appendix A. Detailed discussion of the bases used in developing the minimum charge and any escalated costs appears in Section 3.4 (below).

2.2 Uranium Mill Licensees

Before license termination, licensees are required by license conditions to complete site decontamination and decommissioning, and surface and ground-water remedial actions consistent with NRC-approved (in the case of an NRC licensee) or Agreement State-approved (for an Agreement State licensee) decommissioning, reclamation, and ground-water corrective action plans.

Licensees will need to document the completion of these remedial actions in accordance with procedures developed by NRC or the Agreement State. As discussed in Section 3.1 (below), for NRC licensees, this information will include a report documenting completion of tailings disposal cell construction and accompanying quality assurance/quality control (QA/QC) records, as well as radiation surveys and other information required under 10 CFR 40.42. Agreement State licensees will document their remedial action performance in accordance with the respective State requirements.

Because the LTSP must reflect the remediated condition of the site, the licensee will work with the custodial agency in preparing the LTSP. Most likely, this will involve supplying the custodial agency with appropriate documentation (e.g., as-built drawings) of the remedial actions taken and reaching agreements (formal or informal) with the custodial agency regarding the necessary surveillance control features of the site (e.g., boundary markers, fencing). It is the custodial agency's responsibility to submit the LTSP to NRC for approval. However, the licensee may elect to help prepare the LTSP, to whatever degree is agreed to between the licensee and the custodial agency.

Finally, the licensee provides the funding to cover long-term surveillance of the site, in accordance with Criterion 10 of Appendix A. NRC will determine the final amount of this charge on the basis of final conditions at the site.

After termination of the existing license and transfer of the site and byproduct materials to the custodial agency, a licensee's remaining liability extends solely to any fraudulent or negligent acts committed before the transfer to the custodial agency, as provided for in Section 83b(6) of the AEA.

2.3 Custodial Agency

Section 83 of the AEA states that before termination of the specific license, title to the site and byproduct materials shall be transferred to either (1) the U.S. Department of Energy (DOE); (2) a Federal agency designated by the President; or (3) the State in which the site is located, at the option of the State. It is expected that DOE will be the custodial agency for most, if not all, of the sites.

It is the responsibility of the custodial agency to submit the LTSP to NRC for review and acceptance. Provisions and activities identified in the final LTSP will form the bases of the custodial agency's long-term surveillance at the site. NRC general license in 10 CFR 40.28(a) becomes effective when the licensees current license is terminated and the Commission accepts the LTSP. Custodial agencies are required, under 10 CFR 40.28(c)(1) and (c)(2), to implement the provisions of the LTSP. These activities could include not only those reflected in the LTSP, but also activities voluntarily committed to by the custodial agency.

2.4 States

As discussed in Section 2.3 (above), the State in which the disposal site is located has the option of becoming the custodial agency. This "right of first refusal" may be exercised either on a site-by-site basis or generally covering all sites within the State's limits. This option should be exercised early enough in the license termination process so that termination of the specific license and transfer of the site to the appropriate custodial agency are not delayed unnecessarily. Written confirmation of a State's decision should be documented in a letter to DOE, from the Governor of the State, or another State official to whom the authority for this decision has been appropriately delegated. A copy of this letter must be sent to NRC.

A State's authority over the regulation of the non-radiological constituents of ground water is not impacted by its status, or lack thereof, as a custodial agency for any site within its boundaries. A State's authority, however, does not extend to the radiological constituents of ground water unless it has an 11e.(2) byproduct material program included in its section 274 agreement with the NRC (NRC, 1980b).

In addition to their potential as custodial agencies, Agreement States with an 11e.(2) byproduct material component in their section 274 Agreement with NRC, conduct the reviews of reclamation and decommissioning plans and ground-water corrective action programs for their licensees. For theses reviews, Agreement States use criteria found in their regulations which must be compatible with applicable requirements in Appendix A. Finally, based on a review of their licensees' performance of remedial actions and in accordance with a State-approved plan, Agreement States are responsible for terminating the specific licenses for their licensees. Termination requires NRC's concurrence.

3.0 THE LICENSE TERMINATION PROCESS

A licensee considering termination of its source material license should have in place an acceptable (by NRC or Agreement State, whichever is appropriate) site decommissioning and reclamation plan and if necessary, an acceptable ground-water corrective action program (CAP). This section describes the termination process that follows an NRC licensee's completion of decommissioning, reclamation, and ground-water corrective action in accordance with the approved plans. Specific procedures for NRC's concurrence in the termination of Agreement State licenses.

3.1 Licensee Documentation of Completed Remedial and Decommissioning Actions

3.1.1 Documentation of Completed Surface Remedial Actions

To ensure a timely and efficient NRC review, when reclamation of the tailings disposal cell is completed, the licensee should submit to NRC, for review, a report detailing the conduct and completion of the reclamation construction activities. This Construction Completion Report (CCR) would consist primarily of QA/QC records and as-built drawings. A licensee may refer to the reports prepared by DOE to document completion of remedial actions at UMTRCA Title I Project sites as guidance in developing its CCR. However, some of the information presented in DOE's reports (e.g., original design calculations) has been meant to ease the staff's review rather than to meet documentation requirements.

If a CCR or similar report is not submitted, it will be necessary for the staff to conduct a detailed technical review, to meet its responsibilities under Section 83c of the Act. This review could involve several site visits and significant confirmation testing and would likely involve staff in the following technical disciplines: geotechnical engineering, surface water and erosion protection, and soil radiation cleanup. Accurate QA/QC records and photographs kept by a licensee during cell construction will be important input into the staff's determination that reclamation has been conducted and completed in accordance with the approved plan.

If the NRC determines, as part of its review of the CCR or during a site inspection, that a licensee has neglected to compile QA/QC records or has inadequate records, we may require the licensee to conduct appropriate sampling of those portions of the completed cell that are in question (e.g., of the radon barrier). If a licensee is unwilling or unable to comply, the staff or NRC contractors will conduct the sampling, and the costs involved will be included in the licensing and inspection fees assessed under 10 CFR 170.31. In addition, if a requirement to maintain QA/QC records is part of an approved reclamation plan, a licensee's lack of such records may be interpreted as a violation of the relevant license condition. Appropriate NRC action would be taken in such instances.

3.1.2 Documentation of Completed Site Decommissioning

Licensees are also required, under 10 CFR 40.42(i), to document the results of site decommissioning, which is done by conducting a radiation survey of the premises where the licensed activities were carried out. The results of this survey, the contents of which are specified at 10 CFR 40.42(i)(2), are submitted to NRC for review. A licensee has the option of demonstrating that the premises are suitable for release in a manner other than that specified at 10CFR 40.42. Additional documentation pertinent to site decommissioning and soil cleanup may be required by a specific license condition.

3.1.3 Documentation of Completed Ground-water Corrective Actions

Criteria 5A-5D, along with Criterion 13, of Appendix A, incorporate the basic ground-water protection standards imposed by the U.S. Environmental Protection Agency (EPA) in 40 CFR Part 192, Subparts D and E (48 FR 45926, October 7, 1983). These standards apply during operations and before the end of closure. At a licensed site, if these ground-water protection standards are exceeded, the licensee is required to put into operation a ground-water CAP (Criterion 5D of Appendix A). The objective of the CAP is to return the hazardous constituent concentration levels to the concentration limits set as standards.

For licensees with continuing ground-water cleanup, NRC approval is required for the termination of corrective action. A licensee should submit appropriate ground-water monitoring data and other information that produce reasonable assurance that the ground water has been cleaned to meet the appropriate standards. This may include an application for alternate concentration limits (ACLs) if the licensee concludes that some ACLs for certain constituents are necessary. The staff will review ACLs in accordance with the most current version of the NRC Staff technical position, "Alternate Concentration Limits for Title II Uranium Mills: Standard Format and Content Guide, and Standard Review Plan for Alternate Concentration Limit Applications" (NRC, 1996).

3.2 NRC Review of Completed Closure Actions

On receipt of the CCR, decommissioning report, ground-water completion report, or ACL application, the staff will review the document for completeness and level of detail. Given a favorable finding, the staff will then review the content of the report for documentation that the action has been conducted in accordance with the license requirements and regulations. If that is the case, NRC will notify the licensee by formal correspondence, and, if the licensee so requests, amend the specific license, by deleting applicable license requirements for reclamation, decommissioning, or ground-water cleanup, and identifying requirements for any disposal cell observational period and/or environmental monitoring. As part of its review, staff will conduct site inspections, examining first-hand the closure actions taken, including the QA/QC records.

Additionally, the staff will conduct a final construction-completion inspection, which is expected to consist of a site walk-over and an examination of construction records. No independent verification of completed actions (e.g., confirmatory coring of the radon barrier) is expected, except on a case-by-case basis, as discussed previously.

With respect to construction of the tailings cell, the staff's review of the CCR, coupled with site inspections, will ensure that disposal cells are constructed in accordance with the approved design and done so "correctly" (e.g., QA/QC records show the appropriate number of material lifts have been placed).

The staff will rely on site inspections as the primary means of determining acceptable implementation of the licensee's approved decommissioning plan, especially in regard to soil cleanup. These inspections will consist of (1) reviews of procedures, (2) evaluations of procedure implementation, (3) evaluations of records and quality assurance, and (4) limited gamma surveys and soil sampling. In this way, the staff will gain a needed level of confidence in the licensee's performance to support its evaluation of the final decommissioning survey report. Confirmatory sampling, either by NRC or its contractors, will be conducted at sites for which additional confirmation beyond inspections is necessary. Specific criteria will be employed to identify those sites requiring confirmatory sampling.

3.3 Observation Periods

3.3.1 Following Completion of Surface Remedial Actions

During an observation period following completion of surface remediation, the length of this observational period will be determined on a site-specific basis, with a minimum period of 1 year, commencing at the completion of the erosion cover. Licensees should report significant cell degradation (e.g., the development of settlement or erosional features) occurring during this period.

Sites employing a "full self-sustaining vegetative cover" (Criterion 4 of Appendix A) will be required to have an observation period of at least 2 years, and possibly as long as 5 years, consistent with the bases for Appendix A (NRC, 1980).

A *de facto* observation period may exist at most sites where cleanup of ground-water contamination continues following the completion of surface reclamation (i.e., construction of the tailings disposal cell).

3.3.2 Following Ground-water Remediation

The reviewer shall examine (1) ground-water completion reports, (2) ground-water corrective action reports, or (3) ACL applications to verify that ground-water quality corrective actions have produced a stable water quality and that ground-water monitoring and analysis have been done to confirm the concentration of these contaminants in the ground water and to verify that they meet applicable standards. This shall be done at the end of the 1 year stability groundwater monitoring period.

Ground-water stability monitoring and confirmation of constituents of concern will be acceptable if

(1) A one-time measurement of all constituents of concern has been collected and analyzed from all point-of-compliance wells. A constituent of concern is one that is (a) either (i) currently identified in Part 40, Appendix A, Criterion 13, or (ii) is not listed in Criterion 13, but is placed

in a license condition as part of the staff's review of the Corrective Action Plan; and (b) has been identified in the tailings liquor. NRC has flexibility to add other constituents not identified in Criterion 13. However, in identifying this second set of constituents, the staff should ensure that any additions are made based on a sound technical and regulatory basis. Before requiring additional constituents, the reviewer should determine if such constituents are covered by ongoing State ground-water programs. New constituents should be added in a timely manner, either when the Corrective Action Plan is accepted for review, or at some time during the lifetime of the CAP. New constituents will not be required at the time of the license-termination monitoring submittal.

Some examples of sound technical bases follow:

(a) For the Homestake/Grants and UNC/Churchrock sites, the NRC staff, the U.S. Department of Energy, and the U.S. Environmental Protection Agency will work together to develop an interagency policy on closure and post-closure issues that will comply with the statutory and regulatory missions and requirements of all three agencies. For the Cotter/Canon City and UMETCO/Urivan sites, the State of Colorado is the primary regulatory authority and the NRC has a more limited role. Once all applicable NRC requirements are met, the NRC will have no basis for denying a request to terminate any specific license. However, before the NRC terminates any license for a site on the National Priority List or is subject to continuing regulation by the U.S. Environmental Protection Agency, the NRC will inform the U.S. Department of Energy of the pending action, and where possible, will provide additional time for the U.S. Department of Energy to resolve site issues it may have with the U.S. Environmental Protection Agency.

(b) Trends in ground-water contamination show that after several years of decreasing contamination, the level of contamination begin to rise again.

(c) Surrogate parameters that cover a family of constituents show an increase in the concentration in ground water. Therefore, the staff may require licensees to monitor for all constituents found in that family.

(d) Some constituents used in the milling process, but not listed in Criterion 13, such as ammonia and nitrate, must be addressed.

Constituents should not be added just because an individual State regulatory body is concerned about that constituent. In identifying constituents of regulatory concern not covered in Criterion 13, the reviewer must ensure that an individual State does not use the NRC to implement the ground-water programs that are the responsibility of the State. Having a State identify a constituent as one of concern to the State is not necessarily a proper basis for NRC to include that constituent.

(2) The results of the one-time measurement sampling should be compared with the pre-mining applicable standards as specified in Criterion 5(c) or the license. All hazardous constituents must be shown to meet the standards specified in 5(c) or the license. If this measurement is taken sometime before license termination (3 or more years), the reviewer will need to ensure that recontamination has not occurred. This may be done by taking additional measurements or making analytical calculations.

(3) The stability monitoring data should be inspected for any trends in increasing ground-water concentrations for those constituents of concern in the ground water that were being cleaned up by the Corrective Action Plan.

If the staff reviews result in acceptance of confirmation and stability monitoring, the staff may conclude that

(1) The licensee has monitored all previously identified constituents of concern at the points of compliance.

(2) The post-Corrective Action Plan stability monitoring shows that the constituents of concern that were remediated will remain below compliance or ACL standards.

(3) The one-time sampling for constituents of concern shows that constituents of concern are below and will remain below relevant standards in Part 40, Appendix A, Criteria 5B(5) and 5B(6).

(4) All ground-water Corrective Action Plans have ceased operation.

(5) All identified constituents of concern for which compliance sampling is being conducted have been returned to the concentration limits set as standards.

3.4 Long-Term Site Surveillance Funding

Before termination of the specific license, NRC will set the final amount of the long-term site surveillance charge to be paid by the licensee in accordance with Criterion 10 of Appendix A. NRC's process for determining this amount will include consultations with the licensee and the custodial agency. This charge must be paid to the U.S. general treasury or to the appropriate State agency before of the specific license can be terminated.

3.4.1 Bases for Determination of Surveillance Charge

The basic criterion for tailings disposal is to avoid dependance on perpetual human care and on going maintenance to preserve the isolation of the tailings. NRC, in Criterion 1 of Appendix A, concludes that

> The general goal or broad objective in siting and design decisions is permanent isolation of tailings and associated contaminants by minimizing disturbance and dispersion by natural forces, and to do so without ongoing maintenance.

However, as further indicated in Criterion 1, for practical purposes, specific design and siting considerations must involve finite time limits. For this reason, Criterion 6 contains longevity standards for design of the disposal cell.

In order that the isolation of the tailings and associated contaminants can be preserved to the extent possible, the AEA provides that title to the byproduct material and associated land be transferred to the care of the United States, the State or the tribe, as discussed previously. NRC has interpreted such long-term custody by a governmental agency, whether Federal or State, as "a prudent, added measure of control" (NRC, 1980a), so that land uses that might contribute to the degradation of the cover or lead to direct human exposures can be prevented.

In the “Final Generic Environmental Impact Statement (GEIS) on Uranium Milling” (NRC, 1980a), NRC staff developed the bases for the long-term surveillance charge, given the intent that no ongoing active maintenance of site conditions should be necessary to preserve waste isolation. In the GEIS, the assumptions underlying the so-called "passive monitoring" approach to surveillance of the site are as follows:

(1) An annual visual inspection of the site, either as a site visit or a visual inspection from an aircraft;

(2) No maintenance of equipment or facilities, no fence replacement, and no sampling and no airborne environmental monitoring would be expected;

(3) Essentially, the only costs for continued surveillance/maintenance would consist of time spent in preparing for the inspection, travel to the site, conduct of the inspection, and annual report writing; and

(4) Minimal NRC oversight would be required.

Passive monitoring, thus, would not involve such activities as irrigation, hauling of fill, regrading, or seeding.

Finally, as discussed previously, licensees will contribute the funds necessary to cover the costs of long-term surveillance of their sites. The charge assessed is a one-time fee, which will yeild interest on the funds, assuming a 1 percent annual real interest rate, sufficient to cover the annual costs of site surveillance. The GEIS contains more detailed discussion regarding the determination of this interest rate.

3.4.2 Determination of Surveillance Charge Amount

On the basis of the assumptions discussed in Section 3.4.1 (above), NRC developed the minimum long-term surveillance charge of $250,000 (1978 dollars) as stated in Criterion 10 of Appendix A. It is this charge, adjusted to account for inflation, that the licensee is required to pay this charge which is adjusted to account for inflation, into the general treasury of the United States, or alternately, to the appropriate State agency (if the State is to become the long-term site custodian). The methodology the staff will use to determine the adjusted surveillance charge that accounts for inflationary increases since 1978 includes: (1) using the Consumer Price Index (CPI) available at the time the licensee requests termination and (2) applying the rate of increase for the last month for which it has been calculated to any following month leading to license termination. For example, in June 1996, NRC determined the final surveillance charge for the TVA/Edgemont site. In doing this, the staff used the April 1996 CPI and applied the rate of increase between March and April to the following months.

Criterion 10 does allow for the escalation of this minimum charge, if, on the basis of a site-specific evaluation, the expected site surveillance or control requirements are determined to be significantly greater than those specified in Criterion 12 of Appendix A (i.e., annual inspections to confirm site integrity and determine the need, if any, for maintenance and/or monitoring).

Escalation could result from a licensee's proposal of alternatives to the requirements in Appendix A, as allowed under Section 84c of the AEA. For example, a licensee could demonstrate by analysis that the only mechanism for achieving a minimum disposal cell design life of 200 years at its site is through the use of ongoing maintenance. NRC may approve such a design if it finds that the design will achieve a level of stabilization and containment for the site concerned, and a level of protection of public health and safety, and of the environment, that is equivalent to, to the extent practicable, or more stringent than, the level of protection that would be achieved by meeting NRC's requirements. However, the licensee would likely be required to place additional funds in the long-term surveillance charge to cover the costs of the ongoing maintenance.

Another situation that may lead to the escalation of the minimum charge is the recognition that some degree of active care (e.g., fence upkeep, vegetation control, maintenance of erosional control measures) is necessary to preserve the as-designed conditions of the site. This need should become apparent in the course of site observations during the reclamation and observational periods.

In any case, any escalation in the minimum charge will be discussed with the licensee and long-term custodian, before license termination. Any final variance in the funding requirements will be determined solely by NRC.

A situation may arise in which the custodial agency wants to have commitments in the LTSP that are beyond those required in Appendix A and that NRC does not determine are necessary. In such a case, the amount of the long-term surveillance charge would not be affected (NRC, 1990;"Detailed Comment Analysis," Comment 1.2). The custodial agency will need to identify a mechanism for funding these additional self-imposed requirements.

3.4.3 Payment of Long-Term Surveillance Charge

Licensees may pay the final site surveillance charge directly to the NRC or the custodial agency. If paid to NRC, the funds will be deposited, in accordance with the Miscellaneous Receipts Act, in the U.S. General Treasury. A custodial agency receiving payment from the licensee will need to document receipt and subsequent deposition of the payment. Copies of such documentation should be sent to NRC.

Finally, 10 CFR 150.32(a) provides that when an Agreement State license is terminated and the disposal site is to be transferred to the Federal Government for long-term care, all funds collected by the Agreement State for the purposes of long-term surveillance will be transferred to the United States.

3.5 Preparation of the Long-Term Surveillance Plan

While surface remediation and ground-water cleanup activities are ongoing, it is in the best interest of the licensee to contact the custodial agency with regard to that agency's preparation of the site LTSP. The custodial agency's responsibilities under the general license are defined in the LTSP, the required contents of which are provided at 10 CFR 40.28 and in Criterion 12 of Appendix A, as follows:

- A legal description of the site to be transferred and licensed;

- A detailed description of the site, as a baseline from which future inspectors can determine the nature and seriousness of any changes [licensees may reference previously submitted information, to the extent applicable, in providing this description (10 CFR 40.31(a))];

- A detailed description of the long-term surveillance program, including (1) the frequency of inspections and reporting to the NRC; (2) the frequency and extent of ground-water monitoring, if required; (3) appropriate ground-water concentration limits; and (4) inspection procedures and personnel qualifications;

- The criteria for follow-up inspections in response to observations from routine inspections or extreme natural events; and

- The criteria for instituting maintenance or emergency measures.

In addition to these regulatory requirements, NRC will also require that the LTSP contain documentation of title transfer of the site from the licensee to the custodial agency. This requirement does not apply to sites located on tribal lands, since transfer does not occur for such sites (Criterion 11F of Appendix A).

Because the LTSP must reflect the remediated condition of the site, it is expected that the existing licensee will work with the custodial agency to prepare the LTSP. As discussed in Section 2.2 (above), this will likely involve supplying the custodial agency with appropriate documentation (e.g., as-built drawings) of the remedial actions taken and reaching agreements (formal or informal) with the custodial agency regarding the necessary surveillance control features of the site (e.g., boundary markers, fencing).

As the likely custodial agency for most, if not all, of the sites, DOE has proposed an approach intended to streamline NRC staff reviews of site LTSPs. This approach would involve NRC approval of a "generic LTSP shell" prepared and submitted by DOE. For sites under the long-term care of DOE, significant portions of the LTSP will not change from site to site (e.g., criteria for followup inspections and for instituting maintenance or emergency measures). NRC's approval of the "shell" would cover this generic information, and allow NRC staff to focus its review on the site-specific information in the LTSP. This information would have to reflect site-specific activities that are not to be reflected in the long-term care charge, but are voluntarily committed to by the custodial agency.

3.6 Site Ready for License Termination

When a licensee has completed site reclamation, decommissioning, and, if necessary, ground-water corrective action, and is ready to terminate its specific source material license, it will need to formally notify NRC of its intentions. Such notification should be accompanied by a completed NRC Form 314, "Certificate of Disposition of Materials."

Additionally, an environmental report (ER) is required by 10 CFR 51.60(b)(3) for termination of a license for the possession and use of source material for uranium milling. However, because the environmental impacts associated with reclamation and decommissioning of a uranium mill site will already have been assessed by NRC staff before license termination, licensees seeking license termination can submit a supplemental ER summarizing site decommissioning and reclamation objectives, activities, and results.

Agreement State licensees should apply to their Agreement State for license termination, presenting the appropriate State-required documentation, as needed.

3.7 Termination of the Specific License/Issuance Of The General License

Actual termination of a licensee's specific license and the subsequent placement of the site under the general license provisions of 10 CFR 40.28 will involve a number of separate actions to be completed by NRC. Significant internal coordination (and external, if Agreement State licensees are involved) will be required so that these actions will be completed in an efficient and timely manner, thereby ensuring that the byproduct material and any land used for the disposal of such byproduct material remain under NRC license throughout the process.

3.7.1 NRC Determination Under Section 83c/274c of the Act

Under Section 83c of the AEA for NRC licensees, or Section 274c for Agreement State licensees, NRC must determine whether all applicable standards and requirements have been met by the licensee in the completion of site reclamation, decommissioning, and ground-water corrective action before a licensee's license can be terminated. Necessarily, this determination will rely primarily on NRC or Agreement State reviews and acceptance of the documentation presented by the licensee. In addition, NRC or Agreement State site closure inspection activities, potentially including limited confirmatory radiological surveys, will provide supplemental information for NRC's determination.

For Agreement State licensees, NRC's periodic reviews of the Agreement State's regulatory program will produce confidence that the State's reviews and licensing actions associated with termination have been conducted appropriately, from a technical, administrative, and procedural perspective. The staff will not conduct independent detailed technical reviews of a Agreement State licensee's documentation of completed site decommissioning and reclamation.

3.7.2 NRC Review and Acceptance of the LTSP

An LTSP is required before termination of the specific license and placement of the site and byproduct material under the 10 CFR 40.28 general license. Review and acceptance of the LTSP is the sole purview of NRC. Lack of NRC acceptance of a site LTSP can delay termination of the specific license.

NRC staff's acceptance of an LTSP will be documented in written notification to the custodial agency, and, separately, by noticing the action in the *Federal Register*. In addition, for Agreement State licensees, NRC will also notify the relevant Agreement State of the action.

Issuance of a Specific Order Under 10 CFR 40.28

If NRC has not received an acceptable LTSP for a reclaimed site ready for transfer to the custodial agency, the agency has two options available to it. First, if appropriate, the Commission may choose not to terminate the existing license for a short period of time, while awaiting an acceptable LTSP. Alternately, under 10 CFR 40.28, NRC may issue a specific order to the custodial agency to take custody of the site and to commence long-term surveillance, while the agency prepares the LTSP for final NRC approval.

NRC would require substantial supporting basis to support issuance of an order. The basis would include an understanding of the circumstances leading to the custodial agency's inability to take the site. Factors that the NRC would consider include whether

(1) Adequate notice (at least 16 months) has been provided by the existing licensee to allow the custodial agency to effect title transfer to the land and byproduct material;

(2) Sufficient time (at least 2 years) has been allowed for the custodial agency to prepare, and the NRC to review, the LTSP;

(3) NRC has reviewed the CCR, decommissioning report, and ground-water cleanup report, and conducted the final license-termination inspection and found that the closure actions were completed in an acceptable manner;

(4) Site degradation has occurred, and if it has, whether appropriate repairs have been completed;

(5) The required long-term surveillance funding payments have been made to the U.S. General Treasury or to the designated State agency; and

(6) The custodial agency has an acceptable rationale for delaying inclusion of the site under the general license.

In cases in which DOE or another presidentially designated Federal agency will be the long-term custodian and is unable to take custody of the site because of lack of funding, NRC may still order the agency to take custody. The intended custodial agency will have at most 1 year (i.e., the time by which an annual site inspection is to have been completed) in which to obtain the funds through the necessary appropriations process.

3.7.3 Transfer of Site Control to the Custodial Agency

Given a determination that all applicable standards and requirements have been met and acceptance of the site LTSP, NRC will need to complete the following remaining relevant licensing actions: (1) terminating the specific license by letter of termination addressed to the specific licensee, or concurring in the Agreement State's termination of the specific license; (2) placing the site under the general license in 10 CFR 40.28; (3) noticing, in the *Federal Register*, the completion of these licensing actions; and (4) informing appropriate Federal and State officials directly of the termination of the specific license and the placement of the site under the general license.

For Agreement State licenses, these actions will need to be closely coordinated with the relevant Agreement State. After NRC's concurrence in the proposed action, the Agreement State should be ready to terminate the specific license, and to transfer the long-term care funds to the U.S. General Treasury, on notification from NRC that the LTSP has been accepted. The long-term custodian, for its part, should be prepared to accept title to the land and byproduct material. These final actions should be completed within a relatively short period of time (i.e., within a week).

4.0 ADDITIONAL ISSUES

4.1 UMTRCA Title II Sites on Tribal Lands

For UMTRCA Title II disposal sites on tribal lands, UMTRCA provides that long-term surveillance will be accomplished by the Federal Government and that the licensee (i.e., the custodial agency) will be required to enter into arrangements with NRC to ensure this surveillance. UMTRCA does not state explicitly which Federal agency is responsible for the disposal site. In addition, because these sites are located on tribal lands, no title transfer will occur.

NRC will work out long-term care arrangements for these disposal sites on a case-by-case basis which will probably involve a site access agreement between the Indian tribe, the custodial agency, and NRC, to allow the custodial agency to conduct the required site surveillance. Currently, the only site on tribal lands is Western Nuclear, Inc.'s Sherwood uranium mill, located on the Spokane Indian tribe reservation in eastern Washington State.

4.2 Concurrent Jurisdiction

NRC staff intends to make a good-faith effort in working with the States on issues related to a licensee's completion of remedial actions and preparation for license termination. However, concurrent jurisdictional issues between NRC and the States may arise over the regulation of the non-radiological constituents of ground water (previously, NRC has concluded that it has sole jurisdiction over the radiological ground-water constituents (NRC, 1980b)). Such issues would involve disagreements over the ground-water concentration limits to which licensees must restore, especially when a State's concentration limits for certain constituents are lower than NRC's. Although the NRC will, to the extent possible, accommodate a State's perspective, it retains the right to terminate a specific license should a licensee have completed closure activities in accordance with NRC-approved closure plans. In accordance with Section 83 b.(7) of the Act, the site shall be transferred without cost to the United States or a State (other than administrative and legal costs incurred in carrying out such transfer). Therefore, the NRC agrees that it will not terminate any site-specific license until the site licensee has demonstrated that all issues with state regulatory authorities have been resolved.

Where the issues involved are not those of direct NRC concern, NRC will address such issues with the States or other Federal agencies on a case-by-case basis.

Currently, four sites (two NRC licensees -- the United Nuclear Corporation/ Church Rock site; and the Homestake Mining Company/Grants site -- and two Agreement State licensees -- the Cotter Corp./Canon City and the UMETCO/Uravan sites, both in Colorado) are on the Superfund National Priorities List. For these sites, NRC will need to determine on a case-by-case basis if it is appropriate to terminate any of these licenses.

5.0 REFERENCES

Nuclear Regulatory Commission. 1980a. "Final Generic Environmental Impact Statement on Uranium Milling." NUREG-0706, 3 vols. Washington, D.C.

Nuclear Regulatory Commission. 1980b. "OELD Legal Opinion on Two Questions Relating to Operation of the Uranium Mill Tailings Radiation Control Act of 1978." Shapar, H.K., memorandum to Commissioner Ahearne. Washington, D.C. April 28, 1980.

Nuclear Regulatory Commission. 1990. "Rulemaking Issue (Affirmation): Amendments to 10 CFR Part 40 for General Licenses for the Custody and Long-Term Care of Uranium and Thorium Mill Tailings Disposal Sites." SECY-90-282, Washington, D.C. August 10, 1990.

Nuclear Regulatory Commission. 1996. "Staff Technical Position: Alternate Concentration Limits for Title II Uranium Mills: Standard Format and Content Guide, and Standard Review Plan for Alternate Concentration Limit Applications." Washington, D.C. February 1996.

APPENDIX F

GUIDANCE TO THE NRC STAFF ON EFFLUENT DISPOSAL AT LICENSED URANIUM RECOVERY FACILITIES: CONVENTIONAL MILLS

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GUIDANCE TO THE NRC STAFF ON EFFLUENT DISPOSAL AT LICENSED URANIUM RECOVERY FACILITIES: CONVENTIONAL MILLS

BACKGROUND

NRC-licensed uranium mill recovery facilities produce liquid wastes (i.e., effluent) that require proper disposal. Nuclear Regulatory Commission Office of Nuclear Material Safety and Safeguards policy is presented below.

PURPOSE AND APPLICABILITY

This appendix presents guidance and discusses the technical and regulatory basis for review and evaluation of applications for the disposal of liquid waste. It is primarily intended to guide NRC staff reviews of site-specific applications for disposal of liquid waste.

ONSITE EVAPORATION

Applications for onsite evaporation systems must demonstrate that the proposed disposal facility is designed, operated, and closed in a manner that prevents migration of waste from the evaporation systems to subsurface soil, ground water, or surface water in accordance with 10 CFR Part 40, Appendix A. Applicants must also demonstrate that site-specific ground-water protection standards and monitoring requirements are adequately established to detect any migration of contaminants to the ground water and to implement corrective action to restore ground-water quality if and when necessary as required by the regulations.

If surface impoundments are employed for evaporation, but they are not used for waste disposal, they must comply with the design provisions for surface impoundments [Criterion 5A(1) through Criterion 5A(5)]; installation of liners (Criterion 5E); and seepage control (Criterion 5F) of 10 CFR Part 40, Appendix A. However, if surface impoundments are employed for evaporation and waste disposal, they must comply with the regulatory requirements in 10 CFR Part 40, Appendix A. These include the design provisions for surface impoundments [Criteria 5A(1) through Criterion 5A(5)]; installation of liners (Criterion 5E); and seepage control (Criterion 5F). In addition, evaporation ponds must also meet other generally applicable regulatory provisions in Appendix A, in particular, the site-specific ground-water protection standards and leak detection (Criterion 5B and Criterion 5C); corrective action programs (Criterion 5D); ground-water monitoring requirements (Criterion 7); and closure requirements (Criterion 6).

RELEASE IN SURFACE WATERS

The new source performance standards [40 CFR 440.34(b)] stipulate that for new sources there shall be no discharge of process wastewater to navigable waters from mills using the acid leach, alkaline leach, or combined acid and alkaline leach process for the extraction of uranium.

LAND APPLICATIONS

Proposals for disposing of liquid waste by land applications, including irrigation, must demonstrate that doses are maintained as low as reasonably achievable (ALARA) and within the dose limits in 10 CFR 20.1301. Proposed land application activities must be described in sufficient detail to satisfy the NRC need to assess environmental impacts. This may require analysis to assess the chemical toxicity of radioactive and nonradioactive constituents. Specifically, licensees must submit (1) a description of the waste, including its physical and chemical properties that are important to risk evaluation; (2) the proposed manner and conditions of waste disposal; (3) projected concentrations of radioactive contaminants in the soil; and (4) projected impacts on ground-water and surface water quality, and on land uses, including particularly, crops and vegetation. In addition, projected exposures and health risks must be analyzed that may be associated with radioactive constituents reaching the food chain to ensure that doses are ALARA and within the dose limits in 10 CFR 20.1301. Proposals should include provisions for periodic soil surveys to verify that contaminant levels in the soil do not exceed those projected, and a remediation plan that can be implemented in the event that the projected levels are exceeded. Appropriate State and Federal agency permits must be obtained in accordance with 10 CFR 20.2007 and the applicant will be required to comply with NRC regulatory provisions for decommissioning.

DEEP-WELL INJECTION

Proposals for disposing of liquid waste by injection the waste into deep wells must conform to the regulatory provisions in 10 CFR 20.2002 and demonstrate that doses are ALARA and within the dose limits in 10 CFR 20.1301. The injection facility must be described in sufficient detail to satisfy the NRC need to assess environmental impacts. Specifically, proposals must describe the waste, including its physical and chemical properties important to risk evaluation; the proposed manner and conditions of waste disposal; an analysis and evaluation of pertinent information on the nature of the environment; information on the nature and location of other potentially affected facilities; and analyses and procedures to ensure that doses are ALARA and within the dose limits in 10 CFR 20.1301.

In addition, pursuant to the provisions of 10 CFR 20.2007, proposals for disposal by injection in deep wells must also comply with any other applicable Federal, State, and local government regulations pertaining to deep well injection, and must obtain any necessary permits for this purpose. In particular. proposals must satisfy the U.S. Environmental Protection Agency (EPA) regulatory provisions in 40 CFR Part 146, “Underground Injection Control Program: Criteria and Standards,” and obtain necessary permits from the EPA and/or States authorized by EPA to enforce these provisions. In general, NRC staff will approve applications that satisfy the EPA regulations in accordance with the Underground Injection Control Program and the applicable provisions of 10 CFR Part 20.

Licensees and applicants disposing of effluent by injecting it into deep wells are further required to comply with NRC's regulatory provisions for decommissioning. Wells shall be abandoned in accordance with the requirements of the State engineer.

APPENDIX G

NATIONAL HISTORIC PRESERVATION ACT AND ENDANGERED SPECIES ACT CONSULTATIONS

APPENDIX G

NATIONAL HISTORIC PRESERVATION ACT AND ENDANGERED SPECIES ACT CONSULTATIONS

1.0 BACKGROUND

The National Historic Preservation Act (NHPA) requires Federal agencies to consider the effects of actions licensed by Federal agencies on properties included in or eligible for the *National Register of Historic Places.* The reclamation of a mill could impact historic properties directly (e.g., destruction or alteration of the integrity of a property) or indirectly (e.g., prohibiting access or increasing the potential for vandalism). Similarly, the Endangered Species Act (ESA) requires that Federal agencies consult with the U.S. Fish and Wildlife Service (FWS) on any Federal action that could impact endangered species or their habitats. This appendix presents guidance to the U.S. Nuclear Regulatory Commission (NRC) staff on how to fulfill the NRC's obligations under the NHPA and the ESA.

2.0 NATIONAL HISTORIC PRESERVATION ACT

2.1 Review Procedures

The reviewer should ensure that those historic and cultural resources that could be impacted by proposed mill reclamation have been identified, located, and described in sufficient detail to serve as the basis for subsequent analysis and assessment of these impacts. Historic and cultural resources include districts, sites, buildings, structures, or objects of historical, archaeological, architectural, or cultural significance. The staff should review the results of any surveys conducted by the applicant; the location and significance of any properties that are listed in or eligible for inclusion in the *National Register of Historic Places (National Register)* as a historic place; and any additional information pertaining to the identification and description of historic properties that could be impacted by reclamation of the proposed mill. The descriptions to be provided by this review should be of sufficient detail to permit staff assessment and evaluation of specific impacts to historic and cultural resources from reclamation of the mill.

Regulatory criteria for the review of the historic properties that could be impacted by proposed reclamation of mill are based on the relevant requirements of the following:

! 36 CFR Part 800 defines the process by which a Federal agency conforms to the requirements under Sections 106 and 110 of the NHPA to ensure that agency-licensed undertakings consider the effects of the undertaking on historic properties included in or eligible for the *National Register*. Under this regulation, the Federal agency is required to identify and evaluate all historic properties in the project area, and take measures to mitigate adverse affects.

! 36 CFR Part 63 contains guidance by which historic properties are evaluated and determined eligible for listing on the *National Register*.

The reviewer should take the following steps to obtain the necessary information:

(1) Contact the appropriate State Historic Preservation Officer (SHPO) to determine if there are any historic or cultural properties near the proposed mill site. In areas of Indian tribal land, the Indian tribal agencies may act as the SHPO. SHPO and Tribal Historic Preservation Officer (THPO) lists are found on the Advisory Council on Historic Preservation Internet Home Page (http://www.achp.gov).

(a) NRC can authorize the applicant to initiate consultation with the SHPO or THPO, but remains legally responsible for all findings. Notify the SHPO/THPO when an applicant is so authorized.

(b) Make initial contact by phone and invite the SHPO to participate in the site visit. Then request information from the SHPO by letter.

(c) If the SHPO has comments or information that add to or amplify information given to the applicant, request that the SHPO forward, by letter to the staff, these additional comments.

(2) Contact the Archeology and Ethnography Program (AEP) of the U.S. National Park Service (NPS), U.S. Department of Interior (http://www.cr.nps.gov/aad/). This office has expertise in the area of historic and cultural preservation and is staffed with professionals who can assist in the environmental review and in analyzing the results of the applicant's surveys and investigations.

(3) In consultation with the SHPO, apply the *National Register* criteria outlined by the U.S. Department of the Interior (NPS, 1990; 1991) to all identified historic properties that are on the facility site or that will be directly affected by facility construction. If a property appears to meet the criteria, or if it is questionable whether the criteria are met, the staff should request, in writing, an opinion from the U.S. Department of the Interior about the property's eligibility for inclusion in the *National Register*. The request for determination of eligibility should be sent directly to the Keeper of the National Register of Historic Places, National Park Service, U.S. Department of the Interior, Washington, D.C. 20013-7127.

(4) Have the NPS-AEP staff assist in defining the requirements of additional surveys and investigations that the staff decides should be completed by the applicant, and in reviewing the results of these surveys.

(5) Consult the *National Register* to verify the list of *National Register* properties presented by the licensee. Since a proposed facility can have a visual or audible effect on historic and cultural resources that are located some distance from the proposed facility site, all *National Register* properties within the area of potential effects of the proposed facility or offsite areas should be identified.

(6) Discuss with the SHPO and, where appropriate, the State archaeologist and State historian, the information presented to the applicant by the SHPO. The SHPO can alert the staff to relevant State and local laws, orders, ordinances, or regulations aimed at the preservation of cultural resources within the licensee's State. Discuss with the SHPO any organizations or individuals that might be able to assist in identifying and locating archaeological and historic resources (for example, university and Indian tribal archaeological and historical staffs).

(7) To discourage property vandalism and scavenging, it may be necessary to present information to the SHPO for handling in a confidential manner. Summary information, which does not include site-specific information, could be included in the licensee's and NRC staff's documentation.

(8) Contact the Advisory Council on Historic Preservation if guidance is needed, if there are substantial impacts on important properties, in the event of a disagreement, or if there are issues of concern to Indian tribes or Native Hawaiian organizations.

For license renewals and amendment applications, Appendix A to this Standard Review Plan (SRP) provides guidance for examining facility operations and the approach that should be used in evaluating amendments and renewal applications.

2.2 Acceptance Criteria

The kinds of data and information needed will be affected by site- and facility-specific factors and the degree of detail should be modified according to the anticipated magnitude of the potential impact. Guidance can be found on the NPS Internet Home Page at http://www.cr.nps.gov/nr/nrpubs.html. The licensee should present the following data or information:

(1) a detailed description of any archaeological or historical surveys of the proposed site, including the following:

   (a) the physical extent of the survey. If the entire site was not surveyed, the basis for selecting the area to be surveyed is needed.

   (b) a brief description of the survey techniques used and the reason for the selection of the survey techniques used.

   (c) the qualifications of the surveyors.

   (d) the findings of the survey in sufficient detail to permit a subsequent independent assessment of the impact of the proposed project on archaeological and historic resources.

(2) the results of consultation with Federal, State, local, and affected Indian tribal agencies

(3) the comments of any organizations contacted by the licensee to locate and assess archaeological and historic resources located on or near the proposed mill site

(4) a description of any historic property within the area of potential effects of the mill that are in or have been determined eligible for inclusion in the *National Register* or that are included in State or local registers or inventories of historic and cultural resources

(5) a map indicating the location of all identified historic landmarks and historic places with respect to the location of facilities such as buildings, new roads, well fields, pipelines, surface impoundments, and utilities

(6) a license condition prohibiting work if cultural artifacts are found in locations other than those indicated on this map

(7) the likely impact of the presence of new roads, pipelines, or other utilities on historic and cultural resources

(8) a rating of the aesthetic and scenic quality of the site in accordance with the U.S. Bureau of Land Management (BLM) Visual Resource Management System (BLM, 1984, 1986a, 1986b)

2.3 Evaluation Findings

The following information should usually be briefly described in the Environmental Assessment (EA):

! historic properties listed in or eligible for inclusion in the *National Register*. Any resource considered to be eligible for the *National Register* should have concurrence from the appropriate SHPO

! historic properties included in State or local registers or inventories

! any additional important historic or cultural properties

! the efforts to locate and identify previously recorded archaeological and historic sites

! the overall results and adequacy of any surveys (archival or field) that were conducted by the applicant

! a list of organizations and individuals contacted by the applicant or the NRC staff who provided significant information concerning the location of historic and cultural properties.

If the staff's review results in the acceptance of the characterization of the historic and cultural resources, the following conclusions may be presented in the EA.

> The staff has completed its review of the site characterization information concerned with historic and cultural resources near the _______________ uranium mill facility. This review included an evaluation using the review procedures and the acceptance criteria outlined in Section 2 of Appendix G of NUREG-1620. The licensee has acceptably described the historic and cultural resources near the site. A listing of all nearby areas and properties included or eligible for inclusion in the *National Register of Historic Places* is provided. A map indicates where all historic and cultural resources are located with respect to facilities. A record of the investigation of places and properties with historic and cultural significance, which follows guidance equivalent to that of the National Park Service, is provided. Contact with local tribal authorities is acceptably documented. A letter from the SHPO addressing any issues related to the properties that might be affected by the facilities is included. The licensee has acceptably demonstrated that the SHPO and tribal authorities agree with the planned protection from or determination of lack of conflict with facilities and activities and with any places of importance to the State, Federal, or tribal authorities. The licensee has acceptably rated the aesthetic and scenic quality of the site in accordance with the BLM Visual Resource Inventory and Evaluation System.

> On the basis of the information presented in the application, and the detailed review conducted of the characterization of historic and cultural resources near the

_______________ uranium mill facility, the staff concludes that the information is acceptable and is in compliance with 10 CFR 51.45, which requires a description of the affected environment containing sufficient data to aid the Commission in its conduct of an independent analysis.

2.4 References

10 CFR 51.45, "Environmental report."

36 CFR Part 63, "Determination of Eligibility for Inclusion in the National Register of Historic Places."

36 CFR Part 800, "Protection of Historic and Cultural Properties."

Bureau of Land Management. 1984. "Visual Resource Management." BLM Report 8500.

Bureau of Land Management. 1986a. "Visual Resource Inventory." BLM Report H-8410-1.

Bureau of Land Management. 1986b. "Visual Resource Contrast Rating." BLM Report H-8431-1.

Department of the Interior. 1983. "Archeology and Historic Preservation; Secretary of the Interior's Standards and Guidelines." 48 FR 44716, pp. 44716-44742.

National Historic Preservation Act, as amended, 16 USC 470 *et seq.*

National Park Service (NPS). 1985. "Guidelines for Local Surveys: A Basis for Preservation Planning." *National Register*, Bulletin No. 24. U.S. Washington, D.C. Department of the Interior.

National Park Service (NPS). 1990. "Guidelines for Evaluating and Documenting Traditional Cultural Properties." *National Register*, Bulletin No. 38. Washington, D.C. U.S. Department of the Interior.

National Park Service (NPS). 1991. "How to Apply the National Register Criteria for Evaluation." *National Register*, Bulletin No. 15. Washington, D.C. U.S. Department of the Interior.

3.0 ENDANGERED SPECIES ACT

3.1 Review Procedures

Federal agencies must determine if any proposed actions could impact endangered species or their habitats. For uranium mills, the NRC staff should take into consideration impacts resulting from excavation of clay used in constructing radon barriers or procurement of rocks used in rip rap. Other surface reclamation work, such as the cleanup of windblown tailings, could have the potential to impact endangered animals or plants. Also, the staff should review the processing of any alternate concentration limit (ACL) application if the proposed site is located on or near a river that contains endangered animal or plant species.

Procedures for conducting consultations with the FWS are contained in the endangered species consultation handbook (FWS/NMFS, 1998). The reviewer's analysis should consist of the following steps:

1. Contact the FWS regional office or field office to obtain the list of threatened or endangered plant and animal species that may be present near the site. The attached table indicates the States in each FWS regional office and the method preferred by each regional office for contacting FWS.

2. The licensee may request the species list; however, the NRC must formally designate the licensee in writing (FWS/NMFS, 1998, p. 2-13).

3. If there may be endangered or threatened animal or plant species on or near the site, the reviewer will need to discuss the proposed action with the FWS and may need to ask the licensee to perform a survey and a biological assessment (50 CFR 402.12) to evaluate the potential effects of the action on threatened and endangered species. Either the NRC or the licensee can prepare the biological assessment (FWS/NMFS, 1998, p. 3-11).

4. Each State should be consulted about its own procedures for considering impacts to State-listed species.

3.2 Acceptance Criteria

Acceptance criteria for the consultation with the FWS are based on the relevant requirements of the following:

! Endangered Species Act of 1973, as amended, with respect to identifying threatened and endangered species. Section 7 of the Act (“Interagency Cooperation”) requires the staff to ensure that the licensing action is “not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of the habitat of such species.” Compliance with Section 7 requires consultation with the FWS and/or the National Marine Fisheries Service (NMFS). The FWS will coordinate with the NMFS.

! 10 CFR 51.45(d) with respect to the requirement for licensees to discuss the status of compliance with applicable environmental requirements that have been imposed by Federal agencies

! 40 CFR 1502.25 with respect to consultation requirements and the Endangered Species Act

! 50 CFR Part 402 with respect to FWS regulations

3.3 Evaluation Findings

The EA should discuss the threatened and endangered species that are near the site. If any of these species may be affected by the mill reclamation, discuss the impacts to these species and any measures or controls to limit adverse impacts. For example, special habitat needs should be discussed if the proposed project would potentially disrupt those needs. The reviewer should summarize the consultations with the FWS and the State Fish and Wildlife Agency.

3.4 References

10 CFR 51.45, "Environmental report."

40 CFR 1502.25, "Environmental review and consultation requirements"

50 CFR Part 402, "Interagency Cooperation-Endangered Species Act of 1973, as Amended"

Endangered Species Act of 1973, as amended, 16 USC 1531 *et seq*.

Fish and Wildlife Service and National Marine Fisheries Service. 1998. "Endangered Species Consultation Handbook, Procedures for Conducting Consultation and Conference Activities Under Section 7 of the Endangered Species Act."

U.S. Fish and Wildlife Service
Endangered Species Program Contacts

Washington, D.C. Office

U.S. Fish and Wildlife Service
Division of Endangered Species
Mail Stop 420ARLSQ
1849 C St., N.W., Washington, D.C. 20240

Region One (CA, HI, ID, NV, OR, WA)

Vicki Finn, Chief, Division of Endangered Species
Eastside Federal Complex, 911 NE 11th Ave, Portland, OR 97232
Phone: 503-231-6158
Contact:Call field office (FWS phone numbers available from http://www.fws.gov or FWS/NMFS, 1998)

Region Two (AZ, NM, OK, TX)

Steve Chambers, Chief, Division of Endangered Species
P.O. Box 1306, Albuquerque, NM 87103
Phone: 505-248-6643
Contact: Species list on Internet for each county
Call field supervisor if there are questions

Region Three (IA, IL, IN, MI, MN, MO, OH, WI)

T.J. Miller, Chief, Ecological Services Operations
Federal Building, Ft. Snelling, Twin Cities, MN 55111
Phone: 612-713-5334
Contact: Species list on Internet by county, (except Missouri)
Call field supervisor if there are questions or if the site is in Missouri

Region Four (AL, AR, FL, GA, KY, LA, MS, NC, PR, SC, TN, U.S. VI)

Cynthia Dohner, Programmatic Assistant
Regional Director for Ecological Services
1875 Century Blvd., Suite 200, Atlanta, GA 30345
Phone: 404-679-4156
Contact: Letter to Cynthia Dohner

Region Five (CT, DC, DE, MA, MD, ME, NH, NJ, NY, PA, RI, VA, VT, WV)

Paul Nickerson, Chief, Division of Endangered Species
300 Westgate Center Drive, Hadley, MA 01035
Phone: 413-253-8615
Contact: Call field office

Region Six (CO, KS, MT, NE, ND, SD, UT, WY)

Jill Parker, Division of Endangered Species
P.O. Box 25486, Denver Federal Center, Denver, CO 80225
Contact: Call field office

Region Seven (AK)

Laverne Smith, Division of Endangered Species
1011 E. Tudor Rd., Anchorage, AK 99503
Phone: 907-786-3493
Contact: Letter to Laverne Smith

APPENDIX H

GUIDANCE TO THE NRC STAFF ON THE RADIUM BENCHMARK DOSE APPROACH

APPENDIX H
GUIDANCE TO THE NRC STAFF ON THE RADIUM BENCHMARK DOSE APPROACH

1.0 Background

In 10 CFR 40.4, byproduct material is defined as the tailings or waste produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content, including discrete surface wastes resulting from uranium solution extraction processes. Uranium milling is defined as any activity resulting in byproduct material. Therefore, Part 40, Appendix A, applies to *in situ* leach (ISL), heap leach, and ion-exchange facilities that produce byproduct material, as well as to conventional uranium and thorium mills. This guidance only addresses uranium recovery (UR) facilities because there are no currently licensed or planned thorium mills.

The final rule,“Radiological Criteria for License Termination of Uranium Recovery Facilities,” became effective on June 11, 1999, and added the following paragraph after the “radium in soil” criteria in Appendix A, Criterion 6(6):

> Byproduct material containing concentrations of radionuclides other than radium in soil, and surface activity on remaining structures, must not result in a total effective dose equivalent (TEDE) exceeding the dose from cleanup of radium contaminated soil to the above standard (benchmark dose), and must be at levels which are as low as is reasonably achievable. If more that one residual radionuclide is present in the same 100-square-meter area, the sum of the ratios for each radionuclide, of concentration present to the concentration limit, will not exceed “1" (unity). A calculation of the peak potential annual TEDE within 1000 years to the average member of the critical group that would result from applying the radium standard (not including radon) on the site, must be submitted for approval. The use of decommissioning plans with benchmark doses which exceed 100 mrem/yr, before application of ALARA, requires the approval of the Commission after consideration of the recommendation of the NRC staff. This requirement for dose criteria does not apply to sites that have decommissioning plans for soil and structures approved before the effective date of this rule.

2.0 Radium Benchmark Dose Approach

The general requirements for a decommissioning plan, including verification of soil contamination cleanup, are addressed in Chapter 5.0 of the Standard Review Plan (SRP). This appendix discusses the NRC staff’s evaluation of the radium benchmark dose approach, specifically dose modeling and its application to site cleanup activities that should be addressed in the decommissioning plan for those UR facilities licensed by the NRC and subject to the new requirements for cleanup of contaminated soil and buildings under 10 CFR Part 40, Appendix A, Criterion 6(6), as amended in 1999. The facilities that did not have an approved decommissioning plan at the time the rule became final are required to reduce residual radioactivity, that is, byproduct material, as defined by Part 40, to levels based on the potential dose, excluding radon, resulting from the application of the radium (Ra-226) standard at the site. This is referred to as the radium benchmark dose approach.

This guidance also applies to any revised decommissioning plan submitted for NRC review and approval, after the final rule is effective. However, if a subject licensee can demonstrate that no contaminated buildings will remain, and that soil thorium-230 (Th-230) does not exceed 5 pCi/g (above background) in the surface and 15 pCi/g subsurface soil in any 100-square-meter area that meets the radium standard, and the natural uranium (U-nat, i.e., U-238, U-234, and U-235) level is less than 1 pCi/g above background, radium benchmark dose modeling is not required. If future modeling with site-specific parameters for UR sites indicates that this is not a protective approach, the guidance will be revised. Therefore, it would be prudent for a UR licensee to consider the potential dose from any residual thorium and uranium.

The unity “rule” mentioned in the new paragraph of Criterion 6(6) applies to all licensed residual radionuclides. Therefore, if the ore (processed by the facility), tailings, or process fluid analyses indicate that elevated levels of Th-232 could exist in certain areas after cleanup for Ra-226, some verification samples in those areas should be analyzed for Th-232 or Ra-228. The thorium (Th-232) chain radionuclides (above local background levels) in milling waste would have soil cleanup criteria similar to the uranium chain radionuclides. The staff considers the U.S. Environmental Protection Agency memorandum of February 12, 1998 (Directive No. 9200.4-25) concerning use of 40 CFR Part 192 soil criteria for CERCLA sites, an acceptable approach. This means that the Th-230 and Th-232 should be limited to the same concentration as their radium progeny with the 5 pCi/g (0.19 Bq/g) criterion applying to the sum of the radium (Ra-226 plus Ra-228) as well as the sum of the thorium (Th-230 plus Th-232) above background.

2.1 Radium Benchmark Dose Modeling

2.1.1 Areas of Review

The radium benchmark dose approach involves calculation of the peak potential dose for the site resulting from the 5 pCi/g (0.19 Bq/g) concentration of radium in the surface 15 cm (6 inches) of soil. The dose from the 15 pCi/g (0.56 Bq/g) subsurface radium limit would be calculated for any area that may require subsurface cleanup. The dose modeling review involves examining of the computer code or other calculations employed for the dose estimates, the code or calculation input values and assumptions, and the modeling results (data presentation).

Evaluation of the radium benchmark dose modeling as proposed in the decommissioning plan, requires an understanding of the site conditions and site operations. The relevant site information should be presented in the plan or portions of previously submitted documents (e.g., environmental reports, license renewal applications, reclamation plan, and characterization survey report) should be summarized and referenced.

2.1.2 Review Procedures

The radium benchmark dose modeling review consists of ascertaining that an acceptable dose modeling computer code or other type of calculation has been used; that input parameter values appropriate (reasonable considering long-term conditions and representative of the application) for the site have been used in the modeling; that a realistic (overly conservative is not acceptable as it would result in higher allowable levels of uranium or thorium which would not be ALARA) dose estimate is provided; and that the data presentation is clear and complete.

2.1.3 Acceptance Criteria

The radium benchmark dose modeling results will be acceptable if the dose assessment (modeling) meets the following criteria:

(1) Dose Modeling Codes and Calculations

The assumptions are considered reasonable for the site analysis and the calculations employed are adequate. Reference to documentation concerning the code or calculations is provided (for example, the RESRAD Handbook and Manual (Argonne, 1993a, 1993b)).

The RESRAD code developed by the U.S. Department of Energy (Version 5.82, 1998) (see website http://www.ead.anl.gov/~resrad/avail.html), may be acceptable for dose calculations because, although the RESRAD ground-water calculations have limitations, this does not affect the UR sites that have deep aquifers (ground-water exposure pathway is insignificant). The DandD code developed by the NRC (see website ftp://nwerftp.nwer.sandia.gov/nrc/DandD/; also see http://techconf.llnl.gov/radcri/ then dose assessment) provides conservative default values, but does not, at this time, allow for modeling subsurface soil contamination, and does not allow calculation of source removal due to soil erosion. Neither the RESRAD nor the DandD code would be adequate to model the dose from off site contamination, but codes such as GenII are acceptable.

If the code or calculation's assumptions are not compatible with site conditions, adjustments have been made in the input to adequately reflect site conditions. For example, the RESRAD code assumes a circular contaminated zone. The shape factor (external gamma, code screen R017) must be adjusted for an area that is not circular.

The code and/or calculation provides an estimated annual dose as total effective dose equivalent (TEDE) in mrem/yr. The DandD code provides the annual dose, but RESRAD calculates the highest instantaneous dose. However, RESRAD results are acceptable for long-lived radionuclides that do not move rapidly out of surface soils.

(2) Input Parameter Values

The code/calculation input data are appropriate for the site and represent current or long-term conditions, whichever is more applicable to the time of maximum dose. When code default values are used, they are justified as appropriate (representative) for the site. Excessive conservatism (i.e., upper bound value) is not used as this would result in a higher dose and thus higher levels of uranium and thorium could be allowed to remain on site.

Previously approved MILDOS code input parameter values may not be appropriate, because derived operational doses in the restricted area may be an order of magnitude higher than acceptable doses for areas to be released for unrestricted use.

Site-specific input values are demonstrated to be average values of an adequate sample size. Confidence limits are provided for important parameters so that the level of uncertainty can be estimated for that input value. Alteration of input values considers that some values are interrelated (see draft NUREG-1549, Appendix C) (NRC, 1998a) and relevant parameters are modified accordingly. The preponderance of important parameter values are based on site measurements and not on conservative estimates. One or more models consider the annual average range of parameter values likely to occur within the next 200 years; for important parameters, that can reasonably be estimated. Some other considerations for the input parameter values are as follows:

a. Scenarios for the Critical Group and Exposure Pathways

The scenario(s) chosen to model the potential dose to the average member of the critical group[1] from residual radionuclides at the site reflect reasonable probable future land use. The licensee has considered ranching, mining, home-based business, light industry, and residential farmer scenarios, and has justified the scenarios modeled.

On the basis of one or more of these projected (within 200 years is reasonably foreseeable) land uses to define the critical group(s), the licensee has determined and justified what exposure pathways are probable for potential exposure of the critical group to residual radionuclides at the site. Dairies are not likely to be established in the area of former UR facilities because the climate and soil restrict feed production. Even if some dairy cows were to graze in contaminated areas, the milk would probably be sent for processing (thus diluted), and not be consumed directly at the site. Therefore, milk consumption is not a likely ingestion exposure pathway. Also, a pond in the contaminated area providing a significant quantity of fish for the resident's diet is not likely, so the aquatic exposure pathway may not have to be modeled. However, the external gamma, plant ingestion, and inhalation pathways are likely to be important.

The radon pathway is excluded from the benchmark dose calculation as defined in Criterion 6(6) of Appendix A to 10 CFR Part 40. This also reflects the approach in the main decommissioning rule (radiological criteria for license termination, Part 20 Subpart E).

b. Source Term

If the RESRAD code is used, the input includes lead-210 (Pb-210) at the same input value as for Ra-226. The other radium progeny are automatically included in the code calculations. The chemical form of the contamination in the environment is considered in determining input values related to transport, or inhalation class (retention in the lung) for dose conversion factors.

c. Time Periods

The time periods for calculation of the dose from soil Ra-226 include the 1000-year time frame. The calculated maximum annual dose and the year of occurrence are presented in the results.

(1)As defined in 10 CFR Part 20, "the group of individuals reasonably expected to receive the greatest exposure to residual radioactivity for any applicable set of circumstances."

d. Cover and Contaminated Zone

A cover depth of zero is used in the surface contamination model and a depth of at least 15 cm (6 inches) for the subsurface model. The values for area and depth of contamination are derived from site characterization data. The erosion rate value for the contaminated zone is less than the RESRAD default value because in regions drier than normal, the erosion rate is less, as discussed in the RESRAD Data Collection Handbook (Argonne, 1993a), and the proposed value is justified. The soil properties are based on site data (sandy loam or sandy silty loam are typical for UR sites), and other input parameters are based on this demonstration of site soil type (see RESRAD handbook, pp, 23, 29, 77, and 105) (Argonne, 1993a).

The evapo-transpiration coefficient for the semi-arid UR sites is between 0.6 and 0.99. The precipitation value is based on annual values averaged over at least 20 years, obtained from the site or from a nearby meteorological station.

The irrigation rate value may be zero, or less than a code's default value, if supported by data on county or regional irrigation practices (e.g., zero is acceptable if irrigation water is obtained from a river not a well). The runoff coefficient value is based on the site's soil type, expected land use, and regional morphology.

e. Saturated Zone

The dry bulk density, porosity, "b" parameter, and hydraulic conductivity values are based on local soil properties. The hydraulic gradient for an unconfined aquifer is approximately the slope of the water table. For a confined aquifer, it represents the difference in potentiometric surfaces over a unit distance.

If the RESRAD code is used, the nondispersion model parameter is chosen for areas greater than 1000 square meters (code screen R014), and the well pump rate is based on irrigation, stock, or drinking water well pump rates in the area.

f. Uncontaminated and Unsaturated Strata

The thickness value represents the typical distance from the soil contamination to the saturated zone. Since the upper aquifer at UR sites is often of poor quality and quantity, the depth of the most shallow well used for irrigation or stock water in the region is chosen for the unsaturated zone thickness. A value of 18 meters (60 feet) is typical for most sites and 15 meters (50 feet) for the Nebraska site, but regional data are provided for justification. The density, porosity, and "b" parameter values are similar to those for the saturated zone or any changes are justified.

g. Distribution Coefficients and Leach Rates

The distribution coefficient (Kd) is based on the physical and chemical characteristics of the soil at the site. The leach rate value of zero in the RESRAD code is acceptable as it allows calculation of the value. If a value greater than zero is given, the value is justified.

h. Inhalation

An average inhalation rate value of approximately 8,395 m^3/yr is used for the activity assumed for the rancher or farmer scenario based on a Draft Letter Report (Sandia, 1998a). The mass loading for inhalation (air dust loading factor) value is justified based on the average level of airborne dust in the local region for similar activities as assumed in the model.

i. External Gamma

The shielding factor for gamma is in the range of 0.4 to 0.8 (60 to 20 percent shielding) based on DandD Parameter data (NRC, 1998a) (the DandD code screening default value is 0.55). The factor is influenced by the type (foundation, materials) of the house likely to be built on the site and the gamma energy of the radionuclides under consideration.

The time fractions for indoor and outdoor occupancy are similar to default values in RESRAD and draft guidance developed for the main decommissioning rule (NUREG/CR-5512, Volume 3) (NRC, 1996b). For example, the staff would consider fraction values approximating 0.7 indoors and 0.15 outdoors for a resident working at home, and 0.5 outdoors and 0.25 indoors for the farmer scenario (the remaining fraction allocated to time spent off site).

The site-specific windspeed value is based on adequate site data. The average annual windspeed for the UR sites varies from 7 to 13 mph (3.1 to 5.5 meters/sec). The maximum and annual average windspeed are also considered when evaluating proposed erosion rates.

j. Ingestion

Average consumption values (g/yr) for the various types of foods are based on average values as discussed in NUREG/CR-5512, Volume 3 (NRC, 1996b), or the Sandia Draft Letter Reports (1998a, 1998b) , or otherwise justified. Livestock ingestion parameters are default values, or are otherwise justified.

For sites with more than 100 acres of contamination, the fraction of diet from the contaminated area is assumed to be 0.25 for the farmer scenario (Sandia, 1998a), or is otherwise justified based on current or anticipated regional consumption practices for home-grown food. Because of the low level of precipitation in the areas in which UR facilities are located, extensive gardens or dense animal grazing is not likely, so the percentage of the diet obtained from contaminated areas would be lower than the code default value.

Note that the default plant mass loading factor in the DandD code can reasonably be reduced to 1 percent (Sandia, 1998c). The depth of roots is an important input parameter for UR licensees using the RESRAD code. The value is justified based on the type of crops likely to be grown on the site in the future. For vegetable gardens, a value of 0.3 is more appropriate than the RESRAD default value of 0.9 meters that is reasonable for alfalfa or for a similar deep-rooted plant.

(3) Presentation of Modeling Results

The radium benchmark dose modeling section of the decommissioning plan includes the code or calculation results as the maximum annual dose (TEDE) in mrem/yr, the year that this dose would occur, and the major exposure pathways by percentage of total dose. The modeling section also includes discussion of the likelihood of the various land-use scenarios modeled (reflecting the probable critical groups), and provides the variations in dose (dose distribution) created by changing key parameter values to reflect the range of dose values that are likely to occur on the site. The section also contains the results of a sensitivity analysis (RESRAD code can provide a sensitivity analysis via the graphics function) to identify the important parameters for each scenario.

2.1.4 Evaluation Findings

If the staff's review, as described in this section, results in the acceptance of the radium benchmark dose modeling, the following conclusions may be presented in the technical evaluation report (TER).

> The staff has completed its review of the site benchmark dose modeling for the _______________ uranium mill facility. This review included an evaluation using the review procedures and the acceptance criteria outlined in Section 2.1 of Appendix H of the Title II SRP.
>
> The licensee has provided an acceptable radium benchmark dose model and the staff evaluation determines that (1) the computer code or set of calculations used to model the benchmark dose is appropriate for the site; (2) input parameter values used in each dose assessment model are site-specific or reasonable estimates; (3) the dose modeling results include adequate estimates of dose uncertainty.

2.2 Implementation of the Benchmark Dose

2.2.1 Areas of Review

The results of the radium benchmark dose calculations are used to establish a surface and subsurface soil dose limit for residual radionuclides other than radium, as well as a limit for surface activity on structures that will remain after decommissioning. The staff reviews the licensee's conversion of the benchmark dose limit to soil concentration (pCi/g) or surface activity levels (dpm/100 cm^2) as a first step to determine cleanup levels. Alternatively, the licensee can derive the estimated dose from the uranium or thorium contamination (as discussed in Section 2.1.3) and compare this to the radium benchmark dose.

The reviewer also evaluates the proposed cleanup guideline levels (derived concentration limit) in relation to the ALARA requirement and the unity rule.

2.2.2 Review Procedures

The decommissioning plan section on cleanup criteria will be evaluated for appropriate conversion of the radium standard benchmark dose to cleanup limits for soil uranium and thorium and/or surface activity. The plan will also be examined to ensure reasonable application of ALARA to the cleanup guideline values and application of the unity rule where appropriate.

2.2.3 Acceptance Criteria

(1) The soil concentration limit is derived from the site radium dose estimate. The modeling performed to estimate mrem/year per pCi/g of Th-230 and/or U-nat follows the criteria listed in Section 2.1.3. In addition, the U-nat source term input is represented as percent activity by 48.9 percent U-238, 48.9 percent U-234, and 2.2 percent U-235, or is based on analyses of the ore processed. For a soil uranium criterion (derived concentration limit), the chemical toxicity is considered in deriving a soil concentration limit if soluble forms of uranium are present.

(2) Detailed justification for the inhalation pathway parameters is provided, such as the determination of the chemical form in the environment, to support the inhalation class.

(3) The derived Th-230 soil limit will not cause any 100 square meter (m^2) area to exceed the Ra-226 limit at 1000 years (i.e., current concentrations of Th-230 are less than 14 pCi/g surface and 43 pCi/g subsurface, if Ra-226 is at approximately background levels).

(4) In conjunction with the activity limit, the ALARA principle is considered in setting cleanup levels (derived concentration guideline levels). The ALARA guidance in draft Regulatory Guide 4006 (NRC, 1998b) is considered. The proposed levels allow the licensee to demonstrate that the §40.42 (k) requirements (the premises are suitable for release and reasonable effort has been made to eliminate residual radioactive contamination) can be met.

(5) In recent practice at mill sites, the ALARA principle is implemented by removing about two more inches (5 cm) of soil than is estimated to achieve the radium standard (reduce any possible excess or borderline contamination). At mills, it is generally cheaper to remove more soil than to do sampling and testing that may indicate failure and require additional soil removal plus additional testing.

(6) The unity rule is applied to the cleanup if more than one residual radionuclide is present in a soil verification grid (100 m^2). This means that the sum of the ratios for each radionuclide of the concentration present/concentration limit may ot exceed “1" (i.e., unity).

(7) The subsurface soil standard, if it is to be used, is applied to small areas of deep excavation where at least 15 cm (6 inches) of compacted clean fill is to be placed on the surface and that depth of cover is expected to remain in place for the foreseeable future. The long-term cover depth used in the model is justified.

(8) The surface activity limit for remaining structures is appropriately derived using an approved code or calculation. Because recent conservative dose modeling by NRC staff has indicated that more than 2000 dpm/100 cm^2 alpha (U-nat or uranium chain radionuclides) in habitable buildings (2000 hr/yr) could exceed an effective dose equivalent (EDE) of 25 mrem/yr, the licensee proposed a total (fixed plus removable) average surface activity limit for such buildings that is lower than 2000 dpm/100 cm^2, or a higher value is suitably justified.

(9) If the DandD code is used, data are provided to support that 10 percent or less of the activity is removable; otherwise the resuspension factor is scaled to reflect the site-specific removable fraction. Note that this code assumes that the contamination is only on the floor, which can be overly conservative. If the RESRAD-Build code is used, the modeled distribution of contamination on walls versus floor is justified.

2.2.4 Evaluation Findings

If the staff’s review, as described in this section, results in the acceptance of the application of the radium benchmark dose modeling to the site cleanup criteria, the following conclusions may be presented in the technical evaluation report (TER).

> The staff has completed its review of the proposed implementation of the benchmark dose modeling results for the _______________ uranium mill facility. This review included an evaluation using the review procedures and the acceptance criteria outlined in Section 2.2 of Appendix H of the Title II SRP.

The licensee has provided an acceptable implementation plan of the benchmark dose modeling results to the proposed site cleanup activities, and the staff evaluation determines that (1) the cleanup criteria will allow the licensee to meet §40.42(k) and Part 40, Appendix A, Criterion 6(6) requirements; (2) the soil and structures of the decommissioned site will permit termination of the license because public health and the environment will not be adversely affected by any residual radionuclides.

3.0 References

Argonne National Laboratory (for the U.S. Department of Energy). 1993a. “Data Collection Handbook to Support Modeling the Impacts of Radioactive Material in Soil.” ANL/EAIS-8. April 1993.

Argonne National Laboratory (for the U.S. Department of Energy). 1993b. “Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD, Version 5.0.” ANL/EAD/LD-2. September 1993.

Nuclear Regulatory Commission. 1974. “Termination of Operating Licenses for Nuclear Reactors.” Regulatory Guide 1.86. Washington, D.C. June 1974.

Nuclear Regulatory Commission. 1992. “Residual Radioactive Contamination from Decommissioning.” NUREG/CR-5512, PNL-7994, Vol. 1. Washington, D.C.

Nuclear Regulatory Commission. 1994. Office of Nuclear Material Safety and Safeguards, Division of Waste Management. Policy and Guidance Directive PG-8-08, “Scenarios for Assessing Potential Doses Associated With Residual Radioactivity.” Washington, D.C. May 1994

Nuclear Regulatory Commission. 1996a. “Residual Radioactive Contamination from Decommissioning - User’s Manual.” NUREG/CR-5512, Vol. 2, Washington, D.C. October 1996.

Nuclear Regulatory Commission. 1996b. “Residual Radioactive Contamination from Decommissioning - Parameter Analysis,” Draft for Review. NUREG/CR-5512, Vol. 3. Washington, D.C. April 1996.

Nuclear Regulatory Commission. 1997a. Office of Nuclear Material Safety and Safeguards, “NMSS Handbook for Decommissioning Fuel Cycle and Materials Licensees.” NUREG/BR-0241. Washington, D.C. March 1997.

Nuclear Regulatory Commission. 1997b. Office of Nuclear Material Safety and Safeguards. “Draft Standard Review Plan for In Situ Leach Uranium Extraction License Applications.” NUREG-1569 Washington, D.C. October 1997.

Nuclear Regulatory Commission. 1998a. “Decision Methods for Dose Assessment to Comply With Radiological Criteria for License Termination.” Draft NUREG-1549. Washington, D.C. July 1998.

Nuclear Regulatory Commission. 1998b. “Demonstrating Compliance With the Radiological Criteria for License Termination.” Draft Regulatory Guide 4006. Washington, D.C. August 1998.

Sandia National Laboratories. 1998a. “Review of Parameter Data for the NUREG/CR-5512 Residential Farmer Scenario and Probability Distributions for the DandD Parameter Analysis.” Draft Letter Report. January 30, 1998.

Sandia National Laboratories. 1998b. “Review of Parameter Data for the NUREG/CR-5512 Building Occupancy Scenario and Probability Distributions for the DandD Parameter Analysis.” Draft Letter Report. January 30, 1998.

Sandia National Laboratories. 1998c. “Comparison of the Models and Assumptions Used in the DandD 1.0, RESRAD 5.61, and RESRAD-Build Computer Codes with Respect to the Residential Farmer and Industrial Occupant Scenarios Provided in NUREG/CR-5512.” Draft Report. October 15, 1998.

APPENDIX I

RESPONSE TO COMMENTS ON DRAFT STANDARD REVIEW PLAN

APPENDIX I
RESPONSE TO COMMENTS ON DRAFT STANDARD REVIEW PLAN

INTRODUCTION

This appendix contains the NRC staff's responses to written comments on the Draft "Standard Review Plan for Review of a Reclamation Plan for Mill Tailing Sites Under Title II of the Uranium Mill Tailings Radiation Control Act" (NUREG-1620). The comments, which were submitted during the public comment period in 1999, have been grouped by topic and summarized in the following sections. For each group of comments, this appendix presents the names of the commenters, a summary of the issues raised in the comments, and the NRC staff response to the comments.

GENERAL

COMMENT 1

Commenters
National Mining Association
Rio Algom Mining Company
Wyoming Mining Association

Summary of Issue
The commenters expressed concern that the statement in the Introduction to the draft NUREG-1620 that the SRP is only a guidance document is not emphasized enough and that this document will become a *de facto* regulation. The commenters suggested that the introduction place more emphasis on the fact that this is a guidance document by stating that this document should not inhibit the NRC staff or licensees from deviating from the guidance in the SRP when and where appropriate.

It was further suggested that the flexibility issue be discussed in the beginning of the introduction to bring more attention to it, especially for groups other than reviewers and licensees.

It was further stated that the discussion of data-gathering techniques, analytical protocols, algorithms, and reference documents may be of limited value or even inapplicable at a given site as a result of site-specific circumstances and that this should be explicitly stated in the Introduction.

Response to Comments
The Introduction will be revised to state that this SRP cannot cover all methods of meeting the requirements and that alternate approaches may be necessary in those cases.

COMMENT 2

Commenters
National Mining Association
Wyoming Mining Association

Summary of Issue
The commenters suggested that when NUREG-1623 is referenced, a specific section should be cited so that the reader can go directly to it.

Response to Comments
The staff agrees and will reference specific sections of NUREG-1623 in the main body of the Standard Review Plan.

COMMENT 3

Commenters

National Mining Association
Wyoming Mining Association

Summary of Issue

The commenters noted that eight Title II sites have been exempted from the newer reclamation standards. It is suggested that SECY-95-155 be referenced in NUREG-1620 and the eight sites be listed in the document along with the language from SECY-95-155. Additionally, the meaning of the word "reconfirmation" is less than clear. The reference to alternatives in the last paragraph of page xv should also refer to alternatives to EPA requirements.

Response to Comments

SECY-95-155 will be referenced in the Introduction. However, the eight Title II sites that have been exempted will not be specifically named as they are documented in the SECY paper.

COMMENT 4

Commenters

International Uranium Association
Wyoming Mining Association

Summary of Issue

The commenters noted that one environmental trigger for requiring an EA or EIS is whether there is a controversy at a site. The commenters noted that the definition of a controversy is not stated. Furthermore, the commenters questioned whether this would justify the added time and expense of preparing an EIS.

Response to Comments

Page xii, second full paragraph, item (3) will be changed to "an EIS would be needed if the effects on the quality of the human environment are likely to be highly controversial."

COMMENT 5

Commenters

International Uranium Corporation
Nuclear Energy Institute
Wyoming Mining Association

Summary of Issue

The commenters stated that NUREG-1620 proposes penalizing licensees for attempting alternate methods to those listed. The NRC charges the licensees at an hourly rate for reviewing submittals. By stating that review times may be longer for licensees who propose alternatives, the licensee will be penalized with higher review costs. Commenters suggested that the licensees be encouraged to review and evaluate alternatives for sites, not discouraged from the effort.

Alternatively, one commenter noted that the Introduction indicated the staff is willing to consider proposals for other solutions and approaches on a generic basis to avoid the impact of additional view-time for individual cases. The commenter supported this as an innovative approach to cost- and time-effective use of licensee and NRC staff resources.

Response to Comments
Draft NUREG-1620 does not propose penalizing licensees for proposing alternate methods but only points out that additional review time could be involved in evaluating an alternate method. A well-prepared document on an alternative may not take more time to review. The licensee may present its proposed methodology in a teleconference along with an outline of the plan. With nominal examination of the outline, the staff can inform the licensee of the probable review time that will be required. The licensee can then make a value judgment regarding the feasibility of pursuing alternatives other than those stated in NUREG-1620.

COMMENT 6
Commenter
National Mining Association

Summary of Issues
The Introduction (first paragraph, p. xii) addresses "all applicable requirements" for license termination, discusses completion of stabilization work for tailings and the determination that all standards applicable to groundwater cleanup have been met. The commenter noted that there is no mention of mill decontamination and decommissioning, surface soil cleanup or radium soil, in accordance with the provisions of Criterion 6(6), or cleanup of uranium or thorium in soil in accordance with 64 CFR 17.506. The commenter suggested that it be made clear that each of the referenced requirements are, although interrelated, separate regulatory requirements with which the licensee must comply.

Secondly, the wording in this same paragraph of the document indicates that compliance with these three aspects of reclamation forms a basis for the staff finding that the design and groundwater cleanup program conform to applicable requirements. The commenter noted that for both the licensee and NRC, the text should clearly reflect that all applicable regulatory requirements for surface stabilization are not met until the licensee demonstrates in a one-time test that the radon flux 20pCi/m^2s limit actually has been measured and satisfied.

Response to Comment
The introduction will be revised to include decommissioning of land and buildings (site cleanup). Appendix A, Criterion 6 will be addressed in the final version of Chapter 5, including Criterion 6(2) for the measurement of radon flux.

COMMENT 7
Commenter
National Mining Association

Summary of Issue
The commenter suggested rewording the first sentence in Section 2.1 in Appendix E, which states that before termination NRC must determine whether the licensee has complied with all applicable standards and requirements under its license. The proposed new wording follows: "or a licensee-proposed alternative that provides equivalent or greater protection."

Response to Comment
The text will be reworded. The new wording follows: "the NRC staff determines whether the licensee has met all applicable standards and requirements or a licensee-proposed alternative that meets the standards."

COMMENT 8
Commenter
Pathfinder

Summary of Issues
The commenters expressed some concern about the reclamation plans submitted utilizing current NRC guidance. They fear that the new guidance, if adopted, has the potential to force unneeded and costly reevaluation of plan issues that have already been resolved in accordance with the existing guidance. The commenter recommended that the introduction be clarified so that the new guidance will only be applied to major, substantive amendments to existing reclamation plans.

Response to Comment
This document serves as guidance for reclamation reviewal only. If current submittals meet current Federal regulations, then this updated guidance will not adversely affect licensees.

COMMENT 9
Commenter
Nuclear Energy Institute

Summary of Issues
The commenter expressed concern that the SRP has too broad a scope attempting to provide guidance for assessing both reclamation plans submitted with a license application and license amendments pertaining to facility decommissioning after cessation of milling. The guidance for each circumstance is presented in a confusing manner. Guidance in evaluating the decommissioning plan commitments in a license application is weak. The commenter believes that the SRP should be restructured to provide separate guidance for evaluation of pre-operation and post-operation reclamation plans.

Response to Comment
The staff will clarify the evaluation of decommissioning plans (land or buildings) in SRP Chapter 5.0.

COMMENT 10
Commenter
Nuclear Energy Institute

Summary of Issues
The commenter expressed concern about the length of the SRP and recommended streamlining the chapters, and specifically stated that “Acceptance Criteria” repeat the content of “Areas of Review” in Chapter 1. The commenter further stated that inappropriate guidance documents have been referenced (e.g., reference in Section 2.6.3 to two regulatory guides pertaining to nuclear power plants).

Response to Comment
The staff acknowledges that references pertaining to nuclear power plants have been cited in the guidance document. Historically, such references have been included since portions of the guidance apply, and since it is not justified to rewrite guidance to deal solely with mill reclamation at this time. However, redundant sections of Chapter 1.0 will be deleted

COMMENT 11

Commenter
Nuclear Energy Institute

Summary of Issue
The commenter noted the phrase "that has been designed in accordance with the guidance suggested by the staff" was used throughout the SRP. It is not necessary for the plan to be in accordance with staff guidance, only that the appropriate regulatory requirement should be met in a cost-effective way that is protective of human health and safety and of the environment. The commenter suggested clarification on this point.

Response to Comment
The phrase uses the words noted in order to distinguish this document as guidance only. The wording, where appropriate, will be revised to "that has been designed in accordance with the guidance suggested by the staff or as otherwise approved by the staff."

COMMENT 12

Commenter
Nuclear Energy Institute

Summary of Issue
The commenter suggested that the term "Construction Completion Report" was misleading and that there is no statutory or regulatory requirement for either preparation of such a report or for the SRPs 1- to 5-year observational period to demonstrate stability of the decommissioned impoundment preceeding submittal of the report. The commenter recognized the need for such a report but recommended that it be renamed "Decommissioning Completion Report" in order to avoid any question that a Part 40 licensee has any regulatory requirement to seek a construction permit in the licensing process.

Response to Comment.
We will revise the introduction to indicate that the Construction Completion Report shall document that the construction activities were performed according to the NRC-approved plan and meets applicable regulations.

COMMENT 13

Commenter
Department of Energy

Summary of Issue
The commenter suggested that the language in Appendix D discussing Jurisdictional Agreement on Tribal/Individual Indian Owned Lands is unclear. The commenter stated that ownership of the land by persons of American Indian ancestry does not require an agreement with the tribe. However, land that is part of a reservation or in trust status requires tribal agreement.

Response to Comment
The staff agrees with the comment and the language in the Appendix will be changed.

COMMENT 14

Commenter
Department of Energy

Comment
The commenter suggests adding the words “or the Tribe” to the first sentence in Appendix E, page 8. Tribal lands remain under tribal ownership and do not transfer to a State or Federal Agency. Tribal governments and agencies will continue to oversee surveillance.

Response to Comment
The staff agrees and the document will be modified as suggested.

COMMENT 15

Commenter
Department of Energy

C**omment**
The commenter notes the statement that Federal Register noticing of property acquisition by DOE is only required when the acquisition is done as a Public Land Order (PLO). PLOs are used for transferring the jurisdiction of Federal property from one Federal agency to another.

Response to Comment
The section will be revised to include Federal Register noticing or land transfer order, whichever is appropriate.

COMMENT 16

Commenter
Department of Energy

Comment
The commenter notes that item 3 of Section 2.2.1of Appendix D mentions DOE/Tribe agreements and a waiver of liability from the tribe. This language is from Section 105 of UMTRCA and is only relevant to Title I of UMTRCA and, therefore, should be deleted from the guidance document. Site access agreements for the Title II sites on Tribal lands are covered under Section 83(b)(8) of the AEA and discussed in Appendix E of the SRP.

Response to Comment
The staff agrees and the wording will be changed.

COMMENT 17

Comment
Department of Energy

Summary of Issue

The commenter stated that the reference to the closure at sites regulated under CERCLA is still unresolved. The commenter submitted a white paper further addressing the issue.

Response to Comment
The current version of the SRP will not be changed. The NRC has addressed this issue in the past and chose not to pursue the designation as Lead Agency due to staff and budget limitations.

COMMENT 18

Commenter
Department of Energy

Summary of Issue
The commenter notes that page E-13 contains language to include the NRC as party to the access agreement. The commenter asks for clarification that this is a true requirement or that the test be modified.

Response to Comment
The NRC is not required to be a party in the access agreement but should cooperate with the custodial agency in case NRC requires access to the site after license termination. The statement will not be revised.

GEOLOGY AND SEISMOLOGY

COMMENT 1
Commenters
National Mining Association
Sweetwater Uranium Facility, Kennecott Uranium Company
Wyoming Mining Association

Summary of Issues
The National Mining Association supported the use of a probabilistic seismic hazard analysis (PSHA).

Kennecott and the Wyoming Mining Association asked that a sixth category be added to the list of information in Section 1.4.2:

F. Information in the form of maps, papers, or other data, specific to the area or region, generated by State or Federal agencies or published in the literature.

All three commenters suggested that the following references be added to Section 1.4.5 because these papers address seismic hazards related to regions that contain Title II sites. In addition, the commenters suggested the conclusions of the following documents should be considered in the SRP:

1. James C. Case, 1996. "Recommendations Regarding Seismic Design Standards for Uranium Mill Tailings Sites in Wyoming." Hazards Report 96-1. Wyoming State Geological Survey.

5. Ivan G. Wong, Susan S. Olig, Bruce W. Hassinger, and Richard E. Blubaugh. 1997. "Earthquake Hazards in the Intermountain U.S.: Issues Relevant to Uranium Mill Tailings Disposal," *Tailings and Mine Waste 97*. A.A. Balkema Publishers. pp. 203-212.

6. J. F. Gibbons, 1995, “Seismotectonic Stability -- East Gas Hills Site-- Wyoming.” Prepared for Umetco Minerals Corporation, Grand Junction, Colorado.

Response to Comments
The staff accepts the suggested additional category of information in Section 1.4.2 because it reflects the current staff review procedures.

The report by Case was submitted to the NRC as an attachment to a March 5, 1996, letter from Jim Geringer, Governor of Wyoming, to Joseph Holonich, NRC. The Case report is a critique of the SRP reference by Bernreuter et al. (1994), which is a seismic study of uranium mill tailings sites in Utah, New Mexico, South Dakota, and Wyoming. The Bernreuter report calculates probabilistic hazard estimates of peak ground acceleration (PGA) for an annual probability of exceedance (PE) of 10^{-4} (10% chance of being exceeded in 1000 years) and for a PE of $5x10^{-4}$ (10% chance of being exceeded in 200 years, or a 200-year design life). These probabilistic seismic hazard estimates were calculated for random earthquakes and did not include specific faults in the analysis. The study was intended to be a screening analysis, and the results were used to determine if any additional study was needed at the Title II sites.

The Case report concluded that PGAs with an annual PE of 5×10^{-4} are appropriate seismic design requirements for uranium mill tailings sites in Wyoming. The NRC replied to the Case report on June 27, 1996, in a letter from Joseph Holonich, NRC to James Case, Wyoming Geological Survey. NRC concluded that a 200-year design life may be sufficient for a remote site; however, NRC regulations in 10 CFR Part 40, Appendix A, require that a design for the disposal of tailings from a mill provide “reasonable assurance of control of radiological hazards to ... be effective for 1000 years, to the extent reasonable achievable, and, in any case, for at least 200 years” The staff considered that a 1000-year design life is “reasonable achievable.”

Because the staff does not agree with the conclusion of the Case report, this document will not be added to the references in the SRP. However, to clarify the staff’s position, in SRP Section 1.4.3, “Probabilistic Analysis,” the second sentence will be deleted, and in the fourth sentence, “Bernreuter et al. (1994) contains probabilistic analyses that are acceptable for determining PHAs for the respective mill sites” will be changed to “Bernreuter et al. (1994) contains probabilistic analyses for Title II mill sites.” Also, note that in Section 1.4.3, the staff will consider either a deterministic or a probabilistic seismic hazard analysis as an acceptable method for selecting the PGA for a site.

The 1997 paper by Wong et al. argues for the use of PSHA. Since the 1999 draft SRP states the staff’s acceptance of the use of PSHA, it is not necessary to reference the Wong et al. document in the SRP.

The paper by Dr. Gibbons is a document submitted by a licensee for a specific uranium mill tailings site. Since the public cannot easily obtain this document, it is not included in the SRP reference list.

GEOTECHNICAL STABILITY

COMMENT 1
Commenters
International Uranium Corporation
National Mining Association
Wyoming Mining Association

Summary of Issue
The Wyoming Mining Association (WMA) questioned NRC's authority to regulate borrow area restoration plans (Section 2.1.1). The WMA stated that such borrow areas should be regulated by the State agency that regulates mining operations. The International Uranium Corporation (IUC) stated a similar concern, but acknowledged that NRC evaluation of reclamation costs with respect to the surety was within the realm of NRC concern. The National Mining Association (NMA) also was concerned with NRC review of borrow site reclamation plans, but conceded that NRC concern with environmental impacts of borrow plans was valid.

Response to Comments
NRC concurs that borrow site restoration should be regulated by State agencies. Environmental impacts and reclamation costs as they affect sureties are an NRC concern and will be reviewed by NRC.

COMMENT 2
Commenters
National Mining Assoication
Wyoming Mining Association

Summary of Issue
WMA and NMA suggested that Section 2.2.1 be amended to include, with uranium mill tailings, reference to "other offsite generated 11(e)(2) byproduct materials such as contaminated pipe, tanks, sludges, equipment and other material from uranium in-situ mining operations."

Response to Comments
NRC concurs that references to contaminated pipe, tanks, sludges, equipment and other material from uranium in-situ mining operations may be included in Section 2.2.1.

COMMENT 3
Commenters
International Uranium Corporation
National Mining Association
Wyoming Mining Association

Summary of Issue
The WMA, IUC, and NMA suggested that the SRP should include additional discussion of uncompacted native soil covers and their use in tailings impoundment structures (Section 2.5). The commenters stated that the use of low technology (thick uncompacted native soil) covers is popular because of low cost and the ability of such systems to meet requirements similar to those of NRC.

Response to Comments
NRC has no plans at this time to perform research or a literature search to evaluate the potential for low-technology covers to meet NRC requirements for long-term protection of mill tailings embankments. However, previously issued regulatory guidance on the design and use of native soil covers is available. Should a licensee deem it in its interest to propose using a low technology cover, the plan would be reviewed by NRC and considered satisfactory if all long-term protection features are addressed adequately. The burden of proof of design is on the licensee.

<u>COMMENT 4</u>
Commenter
National Mining Association

Summary of Issue
The NMA suggested that the critical criteria for the distinction between high and low hazard dams should be given in the Final SRP. NMA observed that most uranium mill tailings dams are unlikely to be categorized as high-hazard dams.

Response to Comment.
The NRC published RG 3.11 (Rev 2) in 1977 to address the design, construction, and inspection of embankment retention systems for uranium mills. Also, in 1980, RG 3.11.1 provided information on operational inspection and surveillance of embankment retention systems for uranium mill tailings. Since 1977, there has been some revision to dam safety hazard classification systems. The Federal Agencies that issue engineering guidelines for dam safety hazard classification are currently re-evaluating the definitions for low-hazard, significant-hazard, and high-hazard dam structures. It is unlikely that NRC will modify the dam safety hazard classification system until the Federal Emergency Management Agency issues new overall guidelines. Uranium mill tailings dams in NRC's purview are low hazard structure since there is no potential loss of life to those downstream should any of the structures fail. A brief discussion of the dam safety hazard classification system will be provided in the final SRP.

<u>COMMENT 5</u>
Commenter
National Mining Association

Summary of Issue
The NMA noted that the balance between tight covers above and liners below tailings embankments is problematical. Differences in design philosophy have apparently occurred in two states. Should an imbalance in hydraulic conductivity occur, there is potential for groundwater contamination, "bath-tubbing," and cell instability.

Response to Comment
It is NRC's position that an order-of-magnitude difference between the hydraulic conductivity of the cover and liner should provide sufficient assurance that water will not accumulate in the completed cell. A licensee may be able to show that a larger imbalance than one order of magnitude may be satisfactory for a given site.

COMMENT 6
Commenter
Wyoming Mining Association

Summary of Issue
The WMA suggested that NRC should be more receptive to the use of vegetative covers. The example of a satisfactory vegetative cover at the Kennecott Sweetwater site was presented.

Response to Comment
NRC has existing criteria for the design of vegetative covers. NUREG 1623 contains guidance that the licensee may use to submit a vegetative cover design alternate.

SURFACE WATER HYDROLOGY AND EROSION PROTECTION

COMMENT 1
Commenter
Rio Algom Mining Co.

Summary of Issue
The commenter was concerned that the Standard Review Plan refers to NUREG-1623, which is still in draft form. The commenter would like to see other sources cited in case NUREG-1623 is not finalized before the Standard Review Plan.

Response to Comment
The final version of NUREG-1623 is not expected to be significantly different from the draft version, based on comments received by the staff.

COMMENT 2
Commenter
National Mining Association

Summary of Issue
The commenter highlighted the statements in the Introduction that discuss techniques for assessing channel outlets, sedimentation and diversion channels, construction specifications, quality assurance/quality control programs and so forth. The commenter noted that the requirement in Criterion 4(f) that impoundment design should incorporate features that will promote deposition is not discussed anywhere. If the NRC intends to look at sedimentation in diversion channels, then staff should differentiate between the performance concerns that this raises versus Criterion 4(f)'s promotion of soil deposition. The potential conflict between the two concepts has not been addressed in any depth or detail in this document.

Response to Comment

Criterion 4(f) references impoundment design and the sedimentation associated with it. It states, “The impoundment, where feasible, should be designed to incorporated features which will promote deposition.” It continues with an example that design features should promote the deposition of sediment into the impoundment area in order to increase the cover thickness. The staff does not agree that there is potential conflict between the two concepts; it is simply assuring that the sediment and deposition are beneficial. In the referenced example, the increased sediment will benefit the project by increasing the cover; however, sedimentation in a diversion channel will adversely affect the intended capacity of the ditch and adversely affect the overall integrity of the design. There is no conflict as cited above, both are performance concerns. Additional clarification will be provided in Section 3.4.1 of the SRP.

COMMENT 3

Commenter
National Mining Association

Summary of Issue
The commenter noted that the Introduction states that NUREG-1623 discusses new techniques for assessing, among others, rock durability. The commenter stated that the licensees should have the opportunity to consider using less-durable rock in greater quantities if there are economic and/or aesthetic reasons for so doing. The commenter further stated that NRC should, if possible, address this in an appropriate section of this document or in references to NUREG-1623.

Response to Comment
The staff has revised the rock durability criteria, especially to allow the use of less-durable rock in some applications. Specific criteria for the use of sandstones can be found in NUREG-1623; these criteria can be applied to other rock types of marginal quality. The staff considers that flexibility has already been provided to allow the use of less-durable rock in various applications. The SRP was not changed to address this comment.

COMMENT 4

Commenter
National Mining Association

Summary of Issue
The commenter noted that the SRP addresses the general goals of siting and designing facilities for uranium mill tailings. The commenter suggested that it would be worth noting that such siting decisions are more relevant to new facilities or to extensions of old facilities than to facilities that existed before UMTRCA and the regulations developed in accordance with that act.

Response to Comment
The staff agrees and has clarified SRP Section 3.1.1, “Hydrologic Description of Site,” to indicate that siting criteria may not be applicable to old mills.

COMMENT 5

Commenter

National Mining Association

Summary of Issue
SRP Section 3.2.4 states that the tailings “are disposed of in a manner that does not require active maintenance to preserve condition of the site.” The commenter makes the point that when the critical finding has been made that the licensee’s site stabilization plan is complete and satisfies NRC’s regulatory criteria, the guidance indicates that no active maintenance will be necessary. The licensee does not have liability for damage to the pile after license termination barring some sort of fraud on the part of the licensee. The commenter noted that normal “wear and tear” impacts will be the responsibility of the government custodian if, after license termination based on the NRC “finding” noted above, it turns out that the assumptions, guidance, and criteria as developed by EPA and NRC will not provide the necessary long-term stabilization without active maintenance.

Response to Comment
Staff agrees and does not intend to revisit site designs after transfer to long-term custodian. However, if degradation occurs before site transfer, in accordance with current Commission policy, the licensee will be required to repair the degradation or justify that the design is adequate in light of the observed degradation. The SRP has not been changed.

COMMENT 6
Commenter
National Mining Association

Summary of Issue
Section 3.4.2.2 notes that NUREG-1623 updates the final Staff Technical Position (FSTP) based on experience from Title I and Title II programs and additional research. The commenter noted that specific references to relevant portions or sections of the revised NUREG-1623 should be made in the SRP in order to make it more user friendly.

Response to Comment
The staff agrees and will reference specific sections of NUREG-1623 in the Standard Review Plan.

COMMENT 7
Comment
National Mining Association

Summary of Issue
In Section 3.4.3, the SRP states that the licensee must provide funding for any maintenance required after license termination and that the licensee should work with the long-term custodian to access any additional funding related to long-term surveillance and monitoring. The commenter noted that the language in this section does not make it clear that the licensee will have to negotiate with both NRC and the long-term custodian any additional funds required for active maintenance after license termination. The commenter suggested that the final SRP should specifically indicate that active maintenance is an available “alternative” if there is an appropriate site-specific justification or need.

Response to Comment
Staff agrees and will provide the necessary clarification.

WATER RESOURCES

<u>COMMENT 1</u>
Commenters
Wyoming Mining Association
Rio Algom Mining Co.

Summary of Issue
Some State regulatory bodies may not accept the risk-based criteria that NRC uses and will require the licensee to meet “class of use” standards that are different from those acceptable to the NRC. NRC should clarify what “class of use” standards will be acceptable to the NRC.

The commenter supported the statement in Section 4.1.3 of the Standard Review Plan that constituents of concern should not be added just because an individual State has concerns with that constituent. The commenter was concerned about State regulation of 11(e)(2) byproduct material sites through the regulation of non-radiological components. The commenter believes that NRC should have Federal pre-emptive authority over 11(e)(2) byproduct material.

Response to Comment
In general the NRC uses State “class of use” standards. These standards are usually the same as or stricter than U.S. Environmental Protection Agency (EPA) standards. For any given water quality parameter, the staff may apply NRC requirements if they are stricter than State standards. This is most likely to occur for parameters that do not have EPA standards.

In an OELD legal opinion (NRC, 1980), the NRC concluded that it has sole jurisdiction over radiological constituents in ground water. Concurrent jurisdictional issues between the NRC and Non-Agreement States may arise over the non-radiological constituents of ground water. The staff finds State requirements that are the same as or stricter than NRC requirements acceptable. It is the intent of the NRC staff to make a good-faith effort to work with the States to resolve issues concerning the regulation of non-radiological constituents.

References
Nuclear Regulatory Commission, 1980. "OELD Legal Opinion on Two Questions Relating to Operation of the Uranium Mill Tailings Radiation Control Act of 1978," Shapar, H.K., memorandum to Commissioner Ahearne, April 28, 1980

<u>COMMENT 2</u>
Commenter
Rio Algom Mining Co.

Summary of Issue
Acceptance Criterion 4 of Section 4.4.3 of the draft Standard Review Plan states that adequate waste management practices should be defined as part of an acceptable ground-water remediation plan. Criterion 4 states that if effluents from ground-water corrective action activities are to be discharged to a surface-water body, licensees should obtain a National Pollutant Discharge Elimination System permit. Since ground water from corrective action activities is defined as process effluent, it cannot be discharged to surface waters in accordance with effluent guidance in Appendix F to the Standard Review Plan. The language in Section 4.4.3 and Appendix F to the Standard Review Plan should be consistent.

Response to Comment.
The sentence, "If effluent is to be discharged to a surface-water body, licensees obtain a National Pollutant Discharge Elimination System permit for discharge to surface water" in Criterion 4 of Section 4.4.3 has been deleted.

COMMENT 3
Commenters
International Uranium Corporation
Kennecott Energy
National Mining Association
Wyoming Mining Association

Summary of Issue
Acceptance Criterion 2 of Section 4.4.3 discusses the use of natural flushing as a ground-water corrective action alternative. In developing the rule for Title I sites, EPA stated that natural flushing is consistent with requirements for ground-water corrective actions in the Title II regulations. The use of natural flushing is acceptable as a corrective action alternative in the Title I program and should also be acceptable in the Title II program.

Response to Comments
Although the use of natural flushing is specifically allowed as restoration strategy at Title I mill sites, there are currently no specific regulations in the Title II program that allow the use of natural flushing of contaminated ground water to achieve compliance with ground-water protection standards. This does not preclude the use of natural flushing as an approach for achieving compliance. The introduction to 10 CFR Part 40, Appendix A states that licensees or applicants may propose alternatives to the specific requirements in Appendix A. The Commission may find that the proposed alternatives meet the Commission's requirements if the alternatives will achieve (1) a level of stabilization and containment of the sites concerned and (2) a level of protection for public health, safety, and the environment from radiological and non-radiological hazards associated with the sites that are equivalent to, to the extent practicable, or more stringent than, the level that would be achieved by the requirements of Appendix and the EPA in 40 CFR Part 192, Subparts D and E. However, the staff has never before approved a natural flushing alternative at a Title II site. Therefore, if natural flushing is proposed by a licensee, it may need to be submitted to the Commission as an "issue of first impression." Since the Standard Review Plan should only identify those criteria that are acceptable to the staff, all reference to natural flushing has been removed from the Standard Review Plan.

COMMENT 4
Commenters

Kennecott Energy
Wyoming Mining Association

Summary of Issue
The commenters recommended that a procedure to establish ground-water protection standards approved by the NRC at the Sweetwater site should be included in the SRP as an acceptable procedure. This method was presented at the Society of Mining Engineers meeting in Florida in spring 1998.

Response to Comments
Although not directly mentioned, this method was included in Appendix B of the Standard Review Plan as an acceptable procedure for handling non-detects. However, to make sure the method is adequately described, Appendix B now also references an article by D.R.Heisel "Less Than Obvious - Statistical Treatment of Data Below the Detection Limit", *Environmental Science and Technology* 24:12, pp. 1766-1774, 1990. This article was selected instead of the paper presented at the Society of Mining Engineers meeting, because it was the key reference used in the Sweetwater study and because it is widely available in the public literature.

COMMENT 5
Commenters
Nuclear Energy Institute
National Mining Association

Summary of Issue
Ammonia and nitrate are not listed as constituents of concern in 10 CFR Part 40, Appendix A, Criterion 13 or in 10 CFR Part 40, Appendix A, Table 5(c). Therefore, ammonia and nitrate should not be identified as constituents of concern in the Standard Review Plan. In addition, the mere fact that Criterion 13 says that NRC can, on a case-by-case basis, require the addition of constituents is an insufficient explanation of the NRC's jurisdictional basis for doing so without going through rulemaking. Short of finding that a constituent not listed in Criterion 13 poses an "imminent" risk of significant harm, there would seem to be some question of whether NRC has the authority to order a licensee to add a constituent to its license.

Response to Comments
The ability to add constituents, such as nitrate or ammonia, to the monitoring program of a license in accordance with the NRC's regulations in 10 CFR Part 40, Appendix A, Criterion 13 does not require a rulemaking. Pursuant to section 84 of the Atomic Energy Act of 1954, as amended, the Commission is responsible for ensuring, as "the Commission deems appropriate to protect the public health and safety and the environment," the management of any 11 e.(2) byproduct material. As part of that management, the Commission's regulations require a 10 CFR Part 40 licensee to develop a program to maintain groundwater within the protective concentration limits established by EPA for the hazardous constituents which are listed in Criterion 13. The Commission made it clear, however, that it does not intended for a licensee to be required to monitor for every constituent listed in Criterion 13 and a "reasonable implementation of 5(b)(2) requires serious consideration of what is reasonably expected to be in or derived from the tailings." The Commission has also made it clear that it has the authority to add to this list on a on case-by-case-basis, independent of whether the U.S. Environmental Protection Agency has specified a constituent in 40 CFR Part 192. In addition to the constituents listed in Criterion 13, other constituents may be added based on a careful review of records and data defining which constituents are

likely to be present, or by sampling of the existing tailings to determine which constituents are present. Under its National Environmental Policy Act (NEPA) responsibilities, the Commission must, at certain stages of agency decision making, e.g., at license termination, consider other waste constituents associated with the milling process that have the potential to negatively impact the public health and safety and the environment. This is one of several points at which waste constituents may be added to the list in Criterion 13

The Statement of Consideration for the 1987 final rule for Appendix A (52 FR 43553) specifically addresses nitrate in its discussion of the Commission's authority to add constituents under Criterion 13, pointing out that EPA's drinking-water regulations contain a limit for nitrate, because of a demonstrated health effect for a specific portion of the human population. Another example of a constituent which is not listed in Criterion 13, but has been added to that list on a case-specific bases is ammonia. Ammonia does not typically present a human health or environmental impact in ground water, Environmental impacts may be an issue, however, if ammonia contaminated ground water intercepts surface waters because certain aquatic species, some of which may be endangered, are sensitive to relatively low concentrations of ammonia. Including ammonia in a license on a case-by-case basis under these circumstances would be appropriate, and, in addition, it would allow NRC to comply with requirements in other Federal statutes, such as the Endangered Species Act.

To clarify this position, the Standard Review Plan has been revised as follows:

> Staff may require the addition of constituents associated with the milling process that are not specifically listed in Part 40, Appendix A, Criterion 13, to ground-water monitoring programs These constituents may be added on a case-by-case basis, if they are capable of posing a substantial present or potential hazard to human health or the environment. Before requiring the addition of such constituents, the reviewer should consider whether a constituent is covered by the State ground-water program and whether that program provides an adequate level of protection to human health and the environment. If the staff requires a constituent to be added to the list in Criterion 13, the NRC must establish an associated compliance limit for each added constituent at a level that will be protective of human health and the environment.

COMMENT 6

Commenters

Nuclear Energy Institute
National Mining Association

Summary of Issue

The Standard Review Plan references the application of "supplemental standards" without explaining what these standards are or how they should be established.

Response to Comments

Supplemental standards are a ground-water remediation option permitted in the Title I program. The use of supplemental standards in the Title II program may or may not be acceptable to the NRC staff. Since the Standard Review Plan should only identify those criteria that are acceptable to the staff, all reference to supplemental standards has been removed from the Standard Review Plan.

COMMENT 7

Commenter

Nuclearl Energy Institute

Summary of Issue
The Standard Review Plan contains little discussion of background (or baseline) water quality or methodology of collecting such data.

Response to Comments
Rather than providing pages on ground-water quality sampling methods, monitoring devices, and quality assurance practices the Standard Review Plan identifies published methodologies acceptable to the staff. In Acceptance Criterion 3(b) of Section 4.1.3 it states that "examples of acceptable methods include those that are consistent with ASTM Standards D 4448 for monitor well sampling, D 4696 for unsaturated zone sampling, and D 4840 for chain-of-custody procedures."

COMMENT 8
Commenter
National Mining Association

Summary of Issue
In paragraph 4 on page 4-1 corrective action plans are identified as documents that are submitted by the licensee at the time of the license termination process. However, corrective action plans may be submitted during mill operations as well as during license termination.

Response to Comment
The Standard Review Plan has been revised to state that "Licensees submit corrective action plans **during operations or during the license termination process** to obtain approval of ground-water restoration strategies at sites where ground-water contamination has been detected."

COMMENT 9
Commenter
National Mining Association

Summary of Issue
In acceptance Criterion 3(b)(v) of Section 4.1.3, it is stated that a preoperational monitoring program that has been in place for 1 year consistent with the requirements of Part 40, Appendix A, Criterion 7 is acceptable. However, facilities that existed before the Mill Tailings Act was enacted are unlikely to have such baselines.

Response to Comment
In Acceptance Criterion 3(b) of Section 4.1.3, it is stated that "background water quality may already be defined by a condition in the license. If this is the case, background limits for a ground-water protection standard have already been identified, and the reviewer should rely on those along with any constituents and standards listed in Criterion 5(c) as the regulatory limits applicable to this site." This should be the situation at most if not all of the facilities that existed before 10 CFR Part 40, Appendix A requirements were issued.

In addition, if background water quality was not properly determined before the commencement of any milling activity, Acceptance Criterion 3(d) of Section 4.1.3 refers the reader to Acceptance Criterion 3(c) of Section 4.1.3 and from there to Appendix B. Page B-2 of Appendix B contains guidance on the use of onsite and offsite data to determine the quality of background water.

The following text has been added to Acceptance Criterion 3(b)(v) of Section 4.1.3 to make it clear that many existing facilities will not have a proper pre-mining baseline. "Mills in existence preceding the ground-water compliance provisions of 10 CFR Part 40, Appendix A will have baseline data from a preoperational monitoring program consistent with the requirements of 10 CFR Part 40, Appendix A, Criterion 7."

COMMENT 10

Commenter

National Mining Association

Summary of Issue

Section 4.3 of the Standard Review Plan discusses hazard and as-low-as reasonably achievable assessments for alternate concentration limits. The first paragraph of Section 4.3.1 contains a confusing discussion that mixes acceptable alternate concentration limit (ACL) criteria with special case options outside the ACL framework. This paragraph should be clarified so that it is understood that ACLs that "are not protective of human health and the environment" will not satisfy the ACL framework.

Response to Comment

This paragraph has been modified to state that "ACLs must be protective of human health and the environment at the POE. ACLs that are not protective of human health and the environment will not satisfy the ACL framework."

COMMENT 11

Commenter.

National Mining Association

Summary of Issue

When addressing impacts on endangered species, rather than assess the potential impacts on the population of the species, the potential impacts on the members of the species is assessed rather on members of the species. Therefore, Federal and State water quality criteria may or may not be relevant and/or dispositive.

Response to Comment

Following a sentence on endangered species, the fourth paragraph on page 4-29 of the draft Standard Review Plan contains a sentence that states "aquatic wildlife effects are evaluated by comparing estimated constituent concentrations with Federal and State water-quality criteria." The sentences in the paragraph have been reordered to make it clear that this statement does not apply to endangered species.

COMMENT 12

Commenter

National Mining Association

Summary of Issue
The last sentence of paragraph 4, page 4-23, Section 4.3.3 of the draft Standard Review Plan states that "Section 83.b of the AEA specifically requires that the land used for disposal of any Section 11e(2) byproduct materials be transferred to the Federal Government or State for long-term institutional control." However, in the generic environmental impact statement, NRC indicates that the title transfer provisions, including the regulations in Part 40, Appendix A, are intended to apply to sites used for the disposal of mill tailings, not necessarily other types of byproduct materials, because of the need for long-term surveillance that is typical for such tailings. The agency has stated that only lands on which tailings are disposed of and that, therefore, cannot be completely decontaminated, shall be considered for restricted use; all other lands, including mill site-associated areas, must be completely decontaminated and decommissioned to allow unrestricted use upon license termination. Therefore, the statement that property on which there is *any* byproduct material must be transferred to the State or Federal government is inaccurate.

Response to Comment
The SRP addresses those uranium recovery facilities licensed under 10 CFR Part 40. Consequently, the definition of *byproduct material* in 10 CFR 40.4 applies throughout the document. The draft Standard Review Plan and the offending sentence clearly indicate that the SRP is describing land that is used to *dispose* of 11e(2) byproduct materials. Mill tailings disposal sites contain 11e(2) byproduct material other than mill tailings. For example mill and other contaminated equipment that is also classified as 11e(2) byproduct material is also disposed of in uranium mill tailing disposal sites.

COMMENT 13
Commenter
National Mining Association

Summary of Issue
The final Standard Review Plan should make it clear that there are two concepts of a distant point of compliance. In the first concept, the long-term custodian is required to take the property between the point of compliance and the point of exposure, unless use restrictions make human exposure effectively impossible because the ground water is inaccessible or the ground water is unsuitable for human use. The second concept involves a point of exposure that is beyond the area the long-term custodian must accept for perpetual care.

Response to Comment
There are two approaches to a distant point of compliance. However, they are different from that described in the "Summary of Issue." In the first approach, the long-term custodian would take the property between the point of compliance and the point of exposure. In the second approach the long-term custodian would **not** take the property between the point of compliance and the point of exposure. This might happen when the possibility of human exposure is effectively impossible because the ground water is either inaccessible or unsuitable for use. In any case, whether or not land ownership is invoked, the NRC would need to be assured that no water from the contaminated aquifers would be used on the property between the point of compliance and the point of exposure. The Standard Review Plan has been rewritten to clarify the description of the two approaches.

COMMENT 14

Commenter
National Mining Association

Summary of Issue
In conducting an as-low-as-reasonably-achievable analysis of corrective action target concentration alternatives, it needs to be indicated that alternative target concentrations should be meaningfully different and can be reasonably attained.

Response to Comment
The Standard Review Plan has been modified to state "Corrective-action alternatives should be based on cleanup goals that are at or below the concentration limit determined by the hazard assessment to be protective of human health and the environment. A reasonable range of alternate goals should be evaluated (usually at least three). The goals should be (1) meaningfully different, (2) reasonably attainable by practicable corrective action, and (3) at or below the level identified in the hazard assessment."

<u>COMMENT 15</u>
Commenter
National Mining Association

Summary of Issue
On page 4-36, paragraph 5 of the draft Standard Review Plan the purpose of institutional control is described. However, the explanation of institutional control is far too limited and needs to be expanded on.

Response to Comment
The referenced paragraph is concerned with control of site access by the licensee until site closure. It does not refer to the period after closure. The paragraph has been rewritten to state:

"5) Appropriate site access control is provided by the licensee.

Site access control should be provided by the licensee until site closure to protect human health and the environment from potential harm. Site access control is accomplished by limiting access to the site with a fence and by conducting periodic inspections of the site."

COMMENT 16

Commenter

National Mining Association

Summary of Issue

In Section 3.3.2 (1)(a), page E-6, Appendix E, of the draft Standard Review Plan, the statement is made that "NRC and the EPA agree to use one Federal contact with a licensee, which is NRC." This statement makes little sense, because under UMTRCA NRC is the prime Federal contact.

Response to Comment

The staff agrees. Section 3.3.2(1)(a), page E-6, Appendix E, of the Draft Standard Review Plan has been removed from the Standard Review Plan. However, there are some uranium mill tailings sites that are listed on EPA's National Priorities List (40 CFR Part 300, Appendix B). It is for those sites that NRC and EPA agree to use one Federal contact with the licensee. Clarifying text has been added to the Standard Review Plan to explain NRC's role for sites on EPA's National Priorities List.

COMMENT 17

Commenter

National Mining Association

Summary of Issue.

On page E-12, in the first paragraph of Section 3.7.2 of Appendix E of the draft Standard Review Plan, it is indicated that formal concurrence by other government entities, including the State in which the site is located, is not provided for since those entities have no regulatory authority under the AEA during long-term care. This would not be so if a State ground water permit were in place at the time of license termination or if a non-Agreement State asserted it's right to regulate non-radiological constituents. Such a permit could prevent license termination without the concurrence of the State or other government entities in the Long-Term Surveillance Plan.

Furthermore on pages E-13 and E-14, it states that although NRC will "to the extent possible, accommodate a State's perspective, it retains the right to terminate a specific license should a licensee have completed closure activities in accordance with NRC-approved closure plans." This is in disagreement with paragraph 4 of the "License Termination/Site Transfer Protocol Between the U.S. Department of Energy and the Nuclear Regulatory Commission" dated March 11, 1998 and signed on February 2, 1998, by Jack Tillman (U.S. Department of Energy) and on January 7, 1998, by Joseph J. Holonich (U.S. Nuclear Regulatory Commission).

Response to Comments

The draft Standard Review Plan has been modified to agree with paragraph 4 of the "License Termination/Site Transfer Protocol." The Standard Review Plan now states that "The NRC staff will work cooperatively with DOE and State regulatory authorities and licensees in an attempt to resolve all appropriate groundwater issues preceding termination of the site-specific license and transfer of the site to the DOE. The NRC will not terminate any site-specific license until the site licensee has demonstrated that all issues with State regulatory authorities have been resolved."

COMMENT 18

Commenter
National Mining Association

Summary of Issue
On page E-14, of Section 3.7.2 of Appendix E to the draft Standard Review Plan, it states that currently four sites are on the Superfund National Priorities List and that for these sites, NRC will need to determine if it is appropriate to terminate any of these licenses, on a case-by-case basis. However, further explanation is needed regarding the circumstances under which NRC might consider it inappropriate to terminate such licenses. Paragraph 3 of the “License Termination/Site Transfer Protocol Between the U.S. Department of Energy and the Nuclear Regulatory Commission” dated March 11, 1998 and signed on February 2, 1998 by Jack Tillman (U.S. Department of Energy) and on January 7, 1998 by Joseph J. Holonich (U.S. Nuclear Regulatory Commission) indicates that NRC may have to terminate a license if a licensee has satisfied all appropriate NRC closure requirements.

Response to Comment.
The draft Standard Review Plan has been revised and the following sentences from paragraph 3 of the “License Termination/Site Transfer Protocol” have been added to Section 3.3.2 of Appendix E.

> *For the Homestake/Grants and UNC/Churchrock sites the NRC staff, the U.S. Department of Energy, and the U.S. Environmental Protection Agency will work together to develop an interagency policy on closure and post-closure issues that will meet the statutory and regulatory missions and requirements of all three agencies. For the Cotter/Canon City and UMETCO/Uravan sites, the State of Colorado is the primary regulatory authority. For these two sites, the NRC has a more limited role. Once all applicable NRC requirements are met, the NRC will not have a basis for denying a request to terminate any specific license. However, before the NRC terminates any license for a site on the National Priority List or is subject to continuing regulation by the U.S. Environmental Protection Agency, the NRC will inform the U.S. Department of Energy of the pending action, and where possible, will provide additional time for the U.S. Department of Energy to resolve site issues it may have with the U.S. Environmental Protection Agency.*

<u>COMMENT 19</u>
Commenters
National Mining Association
Nuclear Energy Institute

Summary of Issue
Page 4-29 of the draft Standard Review Plan, it is stated that for alternate concentration limits the combined effects from both radiological and non radiological constituents should be considered. However, the NRC has never provided an explanation or a methodology that it would find acceptable to address the combined effects of radiological and non-radiological constituents.

On page 4-31, the draft Standard Review Plan alludes to guidance in Appendix I to 10 CFR Part 50, Report Number 39, and the International Commission on Radiological Protection (ICRP), Publication Number 22. Both the appendix and the ICRP publication contain no guidance on how the ALARA principle is to be applied to non-radiological hazards and, in particular, to non-radiological hazards that have identifiable hazard thresholds.

Response to Comments
The first paragraph of the Introduction to 10 CFR Part 40, Appendix A states that the term "as low as reasonably achievable" has the same meaning as in §20.1003 of 10 CFR Part 20. This definition in §20.1003 states that "ALARA (acronym for 'as low as is reasonably achievable') means making every reasonable effort to maintain exposure to radiation as far below the dose limits in this part as is practicable...." This would seem to imply that in determining alternate concentration limits, the concept of "as low as reasonably achievable" is only applicable to dose calculations. However the Statements of Consideration for 10 CFR Part 40, publised in the *Federal Register* on November 30, 1988, state that, "The issue of how and when ALARA was intended to apply is not completely clear from the preamble to EPA's final rules [48 FR 45941-2: October 7, 1983] or from the text of the rule itself. However, there is no apparent reason to conclude that any distinction was being made between radioactive and nonradioactive constituents and the Commission accepts EPA's views. The Commission's proposed rule included ALARA for emphasis, but there was no intent to have ALARA dominate the factors to be considered or the fundamental standard that the "constituent will not pose a substantial present or potential hazard to human health or the environment as long as the alternate concentration is not exceeded. The Commission is clarifying these points." The ALARA analysis for non-radiological constituents should be similar to the ALARA analysis for radiological constituents except a "dollar per person rem avoid" value would not be calculated.

RADIOLOGICAL

COMMENT 1
Commenter
Rio Algom Mining Co.

Summary of Issue
The commenter expressed concern with the statement in Section 5.2.1 of the draft SRP pertaining to cleanup of residual radium in areas of the site that are not part of the disposal cell because it is not consistent with the language in 10 CFR Part 40, Appendix A, Criterion 6(6) that states "licensed and/or disposal sites." The uses of the term "disposal cells" imply that only the actual tailings impoundment will be turned over to the long-term surveillance program under restricted conditions.

Response to Comment
The use of "disposal cell" in the statement was intended to reflect the rule statement that any area not meeting the longevity and control of radon release standards (usually associated with a covered disposal cell) would need to meet the radium cleanup standard. This would apply regardless of whether or not the land was turned over to the long-term surveillance program under restricted-use conditions. The "licensed site" referred to in the regulation is not the site under general license to DOE, but the source and byproduct material licensed site, because Criterion 6 addresses closure of the site. The exact wording of Criterion 6(6) will be used in the final SRP, with the text indicating that before license termination, any land of the licensed site must comply either with the radon flux criteria in Criterion 6(1), or with the residual radionuclide criteria in Criterion 6(6).

COMMENT 2
Commenter
Wyoming Mining Association

Summary of Issue
The commenter referred to the discussion of the radon emanation coefficient in Sections 5.1.2 and 5.1.3, and attached "a procedure for measurement of radon emanation coefficients developed in cooperation with NRC...." Also attached were data (presumably produced by that procedure) that were submitted to NRC in 1997, indicating tailings on one site had an emanation coefficient of 0.188. The commenter indicated that the default value of 0.35 is too conservative.

Response to Comment
The procedure submitted in the commenter's attachment was sent by a licensee to the NRC in 1996 after NRC staff expressed concerns that the vacuum method of de-emanation of the soil sample produced much lower radon emanation coefficient values than the oven-drying method of de-emanation. The NRC staff did not cooperate in the development of the procedure that allows either method of de-emanation, and the staff did not approve the procedure.

The NRC staff is aware that uranium mill tailings often have an emanation coefficient of approximately 0.2 (see NUREG/CR-3533, DOE Title I data, etc.), and the value can be affected by the percentage of slimes and sandy tailings. The staff also is aware that windblown tailings have values of approximately 0.25 to 0.45, based on DOE data from 10 mill sites. The default value does not have to be used in the radon model if site-specific data are available or if an alternative value can be justified. There is no reason to change SRP Sections 5.1.2 and 5.1.3.

<u>COMMENT 3</u>
Commenters
Wyoming Mining Association
International Uranium Corporation

Summary of Issue
The commenters referred to the discussion of radon emanation (flux) in Section 5.3.2 concerning means to limit worker inhalation hazard during tailings recontouring or cleanup. Exception was taken to the suggestion that the use of respirators be considered because respirators should only be required when their use is mandated by 10 CFR Part 20 or the licensee's procedures, whichever is more stringent.

Response to Comments
The staff agrees that the use of respirators is unlikely to be justified during tailings recontouring or cleanup. The wording in Section 5.3.2 will be changed to indicate the licensee should provide adequate dust suppression measures and consider the use of other methods to limit the radiological inhalation hazard.

<u>COMMENT 4</u>

Commenters

Wyoming Mining Association
International Uranium Corporation

Summary of Issue

The commenters referred to the discussion in Section 5.3.3 concerning use of "personal dosimeters to assess gamma exposure until the licensee can demonstrate that annual external exposures are less than 10 percent of the limits in 10 CFR Part 20.1201(a)." They pointed out that 10 CFR Part 1502 requires, at a minimum, individual monitoring devices by adults likely to receive a dose (external) in excess of 10 percent of the limits in §20.1201. They indicated that preceding the start of operations, surveys and measurements can determine if individual monitoring will be needed.

Response to Comments

Regulatory Guide 8.30, Section 1.4, recommends that quarterly radiation exposures expected for each category of plant worker should be calculated from the measured radiation levels and predicted occupancy times, to determine the need for personnel monitoring (e.g., film badge or TLD). In addition, personnel monitoring should be used for at least a 1-year period to verify the survey results. The SRP section will be revised to reflect this guidance (noting that Part 20 has annual not quarterly exposure limits) or use of a comparable approach by the licensee.

<u>COMMENT 5</u>

Commenter

Nuclear Energy Institute

Summary of Issue

The commenter indicated that the requirement in Section 5.3.3(2) to specify the "type, range, sensitivity, calibration method and frequency, and availability of monitoring equipment" in a reclamation plan license amendment was overly prescriptive and that such information should not be in a license.

Response to Comment

The information recommended for review in Section 5.3.3(2) would not be specified in a license but the information should be in the reclamation plan quality assurance program. The SRP section will be revised to indicate that the information should be in the reclamation plan in order to provide confidence that the data to be submitted in the final survey report is acceptable to demonstrate compliance with the regulations.

<u>COMMENT 6</u>
Commenter
National Mining Association

Summary of Issue
The commenter indicated that the SRP page 5-2 (Section 5.1.2) discussion of radon flux model parameters should reference the possibility of multiple background concentrations in surrounding soil when assessing background concentration of radium in soil for cover materials.

Response to Comment
Chapter 5 will be expanded to include, under "(4) radium content," discussion of the radium content of the cover and the consideration of multiple background values for soil radium.

<u>COMMENT 7</u>
Commenter
National Mining Association

Summary of Issue
The commenter applauded the NRC staff's flexibility as indicated in the discussion on page 5-11 (Section 5.2.3, item 5) concerning use in verification of the statistical correlation between measured radium in soil and gamma measurements.

Response to Comment
The staff has implemented the recommendation in 40 CFR 192.20 for Title I sites that compliance with the cleanup standards for land and buildings, to the extent practical, be demonstrated through radiation surveys. Also, the NRC staff has indicated in meetings with industry that the degree of correlation and the reliability (sensitivity, accuracy, and precision) of the measurements are considered during the evaluation of the number of soil samples (percentage of grids sampled) proposed for verification in the soil cleanup plan. Further discussion on the gamma-radium correlation will be added to SRP Chapter 5.0.

<u>COMMENT 8</u>
Commenter
Nuclear Energy Institute

Summary of Issue
The commenter indicated that the draft SRP requirements for extensive testing of the proposed cover materials, computer modeling, and a detailed quality assurance program for the data are overly prescriptive. The commenter stated that the licensee should have the flexibility to confirm acceptability of the radon barrier through the final radiological survey (10 CFR 40.42). "How the radon barrier is designed and constructed (clay caps, native soils, etc.) should be the sole prerogative of the licensee."

Response to Comment
The testing and modeling is required to demonstrate compliance with the long-term (200 to 1000 years) radon flux and cover stability criteria in Part 40, Appendix A, Criterion 6(1). Appendix A, Criterion 6(2) requires demonstration that the radon flux limit has been achieved as soon as reasonably achievable after emplacement of the radon barrier. These measurements would not reflect the long-term flux because the

recently placed cover material has a higher moisture content (thus retards radon movement) than is expected to exist years later. Also, in some cases the modeling needs to consider potential freeze-thaw damage (increased porosity, decreased density) to the cover, as well as drying.

The final survey required by 10 CFR 40.42(j)(2) is to demonstrate compliance with soil and building surface cleanup criteria, not disposal cell criteria. Also, the staff has never dictated the type of soil to be used in the radon barrier, but Appendix A does have criteria for the cell and cover (slope, erosion protection, gamma level) that must be addressed. The staff has presented guidance on how the licensee may demonstrate compliance with Appendix A criteria, and the final SRP will indicate that other approaches to demonstrating compliance are to be considered. Also, the introduction to Appendix A indicates that "Licensees or applicants may propose alternatives to the specific requirements in this appendix." This allows the licensee flexibility in the design of the cell cover.

APPENDIX J

TECHNICAL EVALUATION OF APPENDIX A CRITERIA

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During the review process, NRC staff will verify that specific criteria of 10 CFR Part 40, Appendix A have been met. It is suggested that the technical reviewer prepare a list of the specific technical criteria and the method or design used to meet these criteria to be included in the technical evaluation report. The example offered shows one method of documentation.

EXAMPLE OF TECHNICAL EVALUATION OF APPENDIX A CRITERIA:

CONCLUSIONS RELATED TO MEETING APPENDIX A CRITERIA

The staff further concludes that the specific criteria of 10 CFR Part 40 Appendix A are met as follows:

1.C **Demonstrate that erosion, disturbance, and dispersion by natural forces over the long term is minimized.**

The contaminated tailings will be protected from flooding and erosion by an engineered rock riprap layer. The riprap has been designed in accordance with the guidance suggested by the NRC staff (NRC, 1990). The staff considers that erosion protection that meets that guidance will provide adequate protection against erosion and dispersion by natural forces over the long term. As discussed in TER Sections 4.3 and 4.5, adequate protection is provided by (1) selection of proper rainfall and flooding events; (2) selection of appropriate parameters for determining flood discharges; (3) computation of flood discharges using appropriate and/or conservative methods; (4) computation of appropriate flood levels and flood forces associated with the design discharge; (5) use of appropriate methods for determining erosion protection needed to resist the forces produced by the design discharge; (6) selection of a rock type for the riprap layer that will be durable and capable of providing the necessary erosion protection for a long period of time; and (7) placement of a riprap layer in accordance with accepted engineering practice and in accordance with appropriate testing and quality assurance controls.

1.E **Demonstrate that the tailings are disposed of in a manner that does not require active maintenance to preserve conditions at the site.**

As discussed in TER Sections 4.3 and 4.5, the staff considers that the riprap layers proposed will not require active maintenance over the 1000-year design life, for the following reasons: (1) the riprap has been designed to protect the tailings from rainfall and flooding events which have very low probabilities of occurrence over a 1000-year period, resulting in no damage to the layers from those rare events; (2) the rock proposed for the riprap layers is designed to be durable and is not expected to deteriorate significantly over the 1000-year design life; and (3) during construction, the rock layers will be placed in accordance with appropriate engineering and testing practices, minimizing the potential for damage, dispersion, and segregation of the rock.

4.A **Demonstrate that the upstream rainfall catchment areas are minimized to decrease erosion potential and the size of the floods which could erode or wash out sections of the tailings disposal area.**

The site is located in an area that is flooded by offsite floods from Moab Wash and the Colorado River. However, as discussed in the TER, the site is protected from direct onsite precipitation and flooding by engineered riprap layers for the top and side slopes; the tailings disposal cell will need this protection regardless of where it is located. The riprap for the side slopes and drainage ditches is large enough to resist flooding from the minimal flow velocities of floods occurring from a probable maximum flood (PMF) on the Colorado River. A large rock apron has been provided to provide protection against the potential migration of Moab Wash and the Colorado River. The staff therefore concludes that the erosion potential at the site has been acceptably minimized, since any flooding at the site is mitigated by the erosion protection, and the forces associated with offsite floods are minimal.

4.B **Demonstrate that topographic features provide good wind protection.**

The staff considers that the site is adequately protected from wind erosion by the placement of an engineered riprap layer that protects the tailings from surface water erosion. Studies performed for the NRC staff have shown that an engineered riprap layer designed to protect against water erosion will be capable of providing adequate protection against wind erosion.

4.C **Demonstrate that embankments and cover slopes are relatively flat after stabilization to minimize erosion potential and to provide conservative factors of safety assuring long-term stability.**

The relatively flat top and side slopes of the covers will be protected from erosion by an engineered riprap layer which is designed to provide long-term stability (TER Section 4.3). The erosion potential of the covers is minimized by the designing the rock to be sufficiently large to resist flooding and erosion, based on the slope selected. Thus, the staff concludes that the slopes, with their corresponding rock designs, are sufficiently flat to meet this criterion.

4.D **Demonstrate that the rock cover reduces wind and water erosion to negligible levels, including consideration of such factors as the shape, size, composition, and gradation of the rock particles; rock cover thickness and zoning of particle size; and steepness of underlying slopes. Demonstrate that rock fragments are dense, sound, and resistant to abrasion, and free from cracks, seams, and other defects.**

The contaminated tailings will be protected from flooding and erosion by an engineered rock riprap layer. The riprap has been designed in accordance with the guidance suggested by the NRC staff (NRC, 1990). As discussed in Sections 4.3 and 4.5 of the TER, the staff considers that erosion protection which meets that guidance will provide adequate protection against erosion and dispersion by natural forces over the long term. Adequate protection is provided by: (1) selection of proper rainf all and flooding events; (2) selection of appropriate parameters for determining f lood discharges; (3) computation of flood discharges using appropriate and/or conservative methods; (4) computation of appropriate flood levels and flood forces associated with the design discharge; (5) use of appropriate methods for determining erosion protection needed to resist the forces produced by the design discharge; (6) selection of a rock type for the riprap layer that will be durable and capable of providing the necessary erosion protection for a long period of time; and (7) placement of a riprap layer in accordance with accepted engineering practice and in accordance with appropriate testing and quality assurance controls.

12. **Demonstrate that active on-going maintenance is not necessary to preserve isolation.**

As discussed in Sections 4.3 and 4.5 of the TER, the staff considers that the erosion protection will not require active maintenance over the 1000-year design life, for the following reasons: (1) the riprap has been designed to protect the tailings from rainfall and flooding events which have low probablitities of occurrence over a 1000-year period, resulting in no damage to the layers from those rare events; (2) the rock proposed for the riprap layers is designed to be durable and is not expected to deteriorate significantly over the 1000-year design life; and (3) during construction, the rock layers will be placed in accordance with appropriate engineering and testing practices, minimizing the potential for damage, dispersion, and segregation of the rock.